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ANALYSIS OF METHODS USED IN DETERMINING GAME KILL[1]

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Among the statistics essential to sound game administration, none is more vital than that involving reasonably accurate kill figures. Length of the subsequent hunting season, bag limit, and other concessions or restrictions as the case may be, should hinge on the relationship between productivity and take. If existing regulations result in a kill that exceeds productivity, then restrictions are in order; if the kill is well below the replacement rate, liberalization of the game laws is possible. To make game laws without a definite knowledge of the kill is not sound game management.

Even during the years of the recent war, the importance of kill figures became increasingly apparent to state game departments. In 1939, fewer than half of the states attempted to arrive at an annual game kill figure (Gordon 1940) but by 1945, a questionnaire revealed that game departments of all except nine states were making efforts to determine the annual kill, at least of the more important species.

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METHODS USED

In the past decade, some game technicians and administrators have questioned the reliability of methods used to attempt to determine state-wide kill of game. The degree of inaccuracy of various reporting methods has been difficult to determine because of the impossibility of obtaining actual kill data to compare with calculated kill statistics. It is generally agreed that some system of kill accounting is necessary, but some of the "bookkeeping" methods now in use lead to kill figures so erroneous that they often have little value.

The various methods in use by state conservation departments to obtain annual kill statistics may be summarized and defined as follows:

1. *Hunting license report cards,* which will henceforth in this paper be called *license reports,* have been in use in 15 states. A card containing a list of game animals on which the state desires kill data in provided with each hunting

license. The hunter is required by law to fill out the card and send it to the conservation agency within a short specified time after the close of the hunting season.

2. *Hunting license application reports*, hereafter referred to as *application reports*, have been in use in eight states. In this system the hunter is required to list the number of each of the various game animals bagged during the previous season on a blank attached to the current season's license application. The license-issuing agent sends the collected reports to the conservation agency when reporting license fees.

3. *Questionnaires*, sent to a random sample of hunters shortly after the close of the hunting season, are or have been in use by six states to obtain game kill figures. California sent out questionnaires for the 1938 season to supplement kill records obtained from license reports. Indiana uses questionnaires at present more extensively than any other state. Barnes (1946) describes this method in detail.

4. *Tag or seal reports*, have been used by seven states to determine the kill of certain game species, usually big game mammals or turkeys. In this system, a report card is provided with the tag or seal used to mark each kill. In addition to tagging the kill, the hunter is required to fill out the report card and return it to the state agency issuing the tag.

5. *Checking station reports* have been used by four states to calculate the kill of certain game species, largely big game. Generally, use of this system is restricted to one or a few localized areas within a state.

6. *Game warden reports* have been relied upon by three states to obtain a rough estimation of the game kill. In this system, wardens interview hunters in the field to obtain a cross section of the kill in their localities.

7. *Waterfowl club reports* are used by Illinois and Louisiana to obtain data on the kill of ducks and geese. In Illinois record sheets are sent to each group obtaining a club license.

It is proposed in this paper to use several sets of data on the kill of waterfowl in Illinois for evaluating some of the game kill reporting methods.

HUNTING CLUB REPORTS

There were 792 waterfowl club licenses issued in Illinois in 1941, 700 in 1942, and 669 in 1943. Data presented in Table 1 clearly demonstrate that the Illinois River furnishes the bulk of the duck club hunting in the state, followed by the Mississippi River, the Glacial Lakes region in the northeast, and other sections. The Illinois River valley clubs average more members or shooters per club than do those elsewhere and individual club holdings are larger. In 1942, hunters at Illinois River clubs accounted for 74 per cent of the hunter-days and killed 78.5 per cent of the ducks taken by the reporting clubs in the state.

While the Illinois game code requires that all waterfowl clubs report their kill, some—usually the small, temporary ones—fail to report. In 1941, 76 per cent of the registered clubs reported their kill; in 1942, 78 per cent; and, in 1943, 86 per cent. Almost invariably the clubs that killed the largest number of ducks have been the ones to report their kills. Of the 25 largest clubs in the Illinois River valley, only 1 did not

send in its kill record in 1943. There was a fairly close parallel between the duck kill per club in various regions of the state and the per cent of the clubs reporting from those sections; in 1943, 81 per cent of the clubs in the Illinois River valley reported, 77 per cent of those in the Mississippi River valley, 65 per cent of those in the Glacial Lakes region, and 68 per cent of those elsewhere in the state.

The advantages of the club reports are these:

The kill is recorded the day of the hunt; there is no need to memorize it. The register is posted where all club shooters and game officials can inspect it, and there is little chance to "pad" the figures. There is a chance, of course, for collusion of the entire membership of a club to falsify the records, as when hunters are killing over the limit, but such cases are believed to be rare. Some clubs kept kill records long before they were required by law to do so, and others keep them now as a part of their business records. Members of the Natural History Survey staff have checked many club records against actual bag inspections and have found a high degree of accuracy. Because duck club records are believed to give the most reliable duck kill data obtainable, they are used in the following paragraphs as a basis for obtaining figures on the kill of waterfowl in Illinois. These figures are compared to those obtained from hunting license reports.

TABLE 1.—NUMBER OF MEMBERS, DAYS HUNTED, AND DUCK KILL REPORTED BY PRIVATE CLUBS IN FOUR REGIONS OF ILLINOIS, 1942.*

Region	No. clubs reporting	Av. no. members per club	Total no. hunter days	Total duck kill	No. ducks per member per season	Av. kill per club season
Illinois River	275	11.9	11,560	72,807	22.1	264.7
Mississippi River	72	9.5	2,200	10,944	16.0	152.0
Glacial Lakes	55	7.6	1,262	7,156	17.1	130.1
Elsewhere	27	6.1	596	1,805	11.0	66.9
Total or Average	429	10.6	15,618	92,712	20.4	216.1

* Does not include the 42 clubs in Alexander County devoted principally to the shooting of Canada geese. Forty-five other clubs reported the duck kill but did not list the number of members.

KILL CALCULATIONS BASED UPON ACREAGE

In a previous study (Bellrose 1944), the number of ducks bagged per acre at duck clubs reporting in the Illinois River valley, 1940–1942, was given. Data were included on the total number of ducks bagged by reporting clubs, but these figures did not represent the total for the valley because they did not include all the clubs, any of the many individuals who hunt on private lands which are not owned or controlled by a club, the freelance hunters who hunt on public shooting grounds, odd tracts where trespassing is permitted, or in corn fields.

Careful observations indicate that the number of ducks killed per acre by reporting clubs holds good for other privately owned marshlands where ducks are hunted in the Illinois River valley.

From maps, scaled 5¼ inches to the mile, it was determined that in 1940, when water conditions approached normal, there were 72,000 acres of waterfowl habitat—open water, marsh, and swamp—owned or controlled by clubs or individuals. In 1941 and 1942, when high water prevailed, there were about 90,000 acres, because additional lands were inundated and used for duck hunting (Table 2).

TABLE 2.—DUCK KILL IN THE ILLINOIS RIVER VALLEY, 1941–1942.

Year	Number of ducks killed per acre on privately owned lands	Number of acres privately owned	Calculated number of ducks killed on private lands	Number of ducks reported killed on public grounds	Estimated number of ducks killed in corn fields	Total number of ducks killed
1941	1.49	90,000	134,100	7,850	20,000	161,950
1942	1.46	90,000	131,400	12,891	10,000	154,291

The number of ducks killed at public shooting grounds, 1940–1942, in the Illinois River valley has been given in detail in a previous paper (Bellrose 1944), and summarized data from that paper have been included in Table 2. Where the duck kill total, based upon the kill per acre at private grounds, and the public shooting ground kill (as recorded by boat yard operators) are deemed reliable, figures on ducks bagged in corn fields are merely guesses. Nevertheless the corn field figures are based upon the known kill made in certain fields and on extensive observations of ducks and of hunter success in corn fields. At best the duck kill in corn fields make up only a small part of the total kill.

Because of the comparatively few private clubs and the greater diversity of waterfowl habitat in other regions—Mississippi River, Glacial Lakes, ponds, streams, and ditches—it was not feasible to obtain duck kill data for these other regions by the method outlined for the Illinois River valley.

KILL CALCULATIONS BASED UPON BAND RETURNS

Between 1938 and 1943, about 45,000 ducks were banded in Illinois; band returns show that about 2,500 of these birds were killed by Illinois hunters. Assuming that the reported club kill of waterfowl was fairly accurate for reasons already explained, the non-club kill might be arrived at by obtaining a ratio between banded ducks killed by club hunters and those killed by non-club hunters. Theoretically, if club and non-club hunters turned in the same number of bands, the club kill and non-club kill would be equal.

To arrive at the ratio between band returns from club and non-club hunters it was necessary to list the club members and then check band returns against the names on the list. After following that procedure in 1941 and 1942, it was decided in 1943 to expedite the study by sending questionnaires to all Illinois hunters who returned bands in

that year (Table 3). Of the 360 questionnaires sent out, the 231 returned indicated that 123 banded ducks had been killed on club grounds and 108 elsewhere. It was suspected, however, that these numbers did not represent the true ratio between the club and non-club kill. Most of the intensive studies of the Natural History Survey had proportion of ducks were taken by club hunters in the Illinois River valley than in other regions; because of the location of the two banding stations an excessive proportion of the band returns were also from the Illinois valley. Therefore, if statewide figures on the club kill of ducks and on the band returns were used to calculate the total

TABLE 3.—NUMBER OF BANDED DUCKS KILLED BY HUNTERS REPORTING ON DUCK CLUB RECORDS, AND BY HUNTERS NOT REPORTING KILLS ON CLUB RECORDS.

Region of Illinois	1941 band returns		1942 band returns		1943 band returns	
	From hunters reporting kill	From hunters not reporting kill	From hunters reporting kill	From hunters not reporting kill	From hunters reporting kill	From hunters not reporting kill
Illinois River	147	103	307	286	109	58
Mississippi River	3	15	6	23	6	25
Glacial Lakes	1	7	11	35	5	13
Elsewhere	2	20	4	112	3	12
Total	153	145	328	456	123	108

centered around clubs; therefore, it seemed probable that club hunters would return a larger percentage of bands they obtained than would non-club hunters. A thousand questionnaires circulated among a random sample of waterfowlers and a return of 509 of them proved this suspicion well founded. It was learned that club hunters reported 82 per cent of the bands they recovered and non-club hunters 74 per cent. The return ratio between club and non-club hunters was therefore corrected to compensate for differences in the return of bands by these two groups of hunters. That is, 109 bands actually returned (Table 3) represents 82 per cent of a total of 133 bands, the number that should have been returned (Table 6).

In relation to the total kill, a greater state duck kill, the high proportion of ducks killed and bands returned by clubs in the Illinois River valley would unduly weight the total state kill statistics. To avoid this distortion, band returns and club kill were separated into the same four regional categories used previously in this paper: Illinois River valley, Mississippi River valley, Glacial Lakes region, and other sections of Illinois, in Tables 4, 5, and 6. The duck kill figures obtained by this method and shown in Table 7 are markedly higher than would be obtained by using total club kill and band returns for the entire state.

LICENSE REPORTS

In 1941, license reports replaced application reports as a means of determining the Illinois game kill. Illinois

TABLE 4.—ILLINOIS DUCK KILL DETERMINED FROM REPORTED CLUB KILL AND FROM THE RELATIONSHIP OF BAND RETURNS BETWEEN REPORTING CLUB HUNTERS AND NON-REPORTING HUNTERS, 1941.

	Number of band returns*				
Region of Illinois	Reported kill	From hunters reporting kill	From hunters not reporting kill	Calculated unreported kill	Total calculated kill
Illinois River	89,628	179	139	69,551	159,179
Mississippi River	8,845	4	20	44,225	53,070
Glacial Lakes	2,162	1	9	19,458	21,620
Elsewhere	2,000	2	27	27,000	29,000
Total	102,635			160,234	262,869

* Corrected for unreported bands by club and non-club hunters.

TABLE 5.—ILLINOIS DUCK KILL DETERMINED FROM REPORTED CLUB KILL AND FROM THE RELATIONSHIP OF BAND RETURNS BETWEEN REPORTING CLUB HUNTERS AND NON-REPORTING HUNTERS, 1942.

	Number of band returns*				
Region of Illinois	Reported kill	From hunters reporting kill	From hunters not reporting kill	Calculated unreported kill	Total calculated kill
Illinois River	72,807	374	349	74,991	147,798
Mississippi River	10,944	7	28	48,482	59,425
Glacial Lakes	7,156	13	43	33,061	40,218
Elsewhere	1,805	5	137	54,511	56,316
Total	92,712			211,045	303,757

* Corrected for unreported bands by club and non-club hunters.

TABLE 6.—ILLINOIS DUCK KILL DETERMINED FROM THE CALCULATED CLUB KILL AND FROM THE RELATIONSHIP OF BAND RETURNS BETWEEN CLUB HUNTERS AND NON-CLUB HUNTERS, 1943.

	Number of band returns*				
Region of Illinois	Reported kill	From hunters reporting kill	From hunters not reporting kill	Calculated unreported kill	Total calculated kill
Illinois River	104,200	133	78	61,478	165,678
Mississippi River	23,520	7	34	114,307	137,827
Glacial Lakes	4,355	6	18	13,065	17,420
Elsewhere	3,608	4	16	14,432	18,040
Total	135,683			103,282	338,965

* Corrected for unreported bands by club and non-club hunters.

hunters turned in 75 per cent of the report blanks issued in 1941, 55 per cent of those issued in 1942, and 26 per cent of those issued in 1943. William Cloe, leader of Illinois Federal Aid Project 21-R, Illinois Department of Conservation, tabulated the game figures from a random sample of these reports for 1941 and 1942. The writer calculated the duck kill figures from a random sample of the 1943 kill reports.

number of ducks bagged per hunter per year was obtained from many thousands of reports, and the average was multiplied by the number of hunting licenses issued during the year to obtain the total kill figure.

Tabulations based on figures obtained from application reports give the number of ducks killed, 1936, 1937, and 1938, respectively, as 520,937, 525,986, and 855,746.

TABLE 7.—ILLINOIS DUCK KILL FIGURES CALCULATED FROM BAND RETURNS, FROM LICENSE REPORTS, AND FROM LICENSE REPORTS WITHOUT COMPENSATION FOR NON-REPORTING HUNTERS.

Year	Duck kill calculated from band returns	Duck kill calculated from license reports	Uncorrected duck kill from license reports	Per cent of hunters submitting license reports
1941	262,869	493,552	370,164	75
1942	303,757	625,964	344,280	55
1943	338,965	671,602	174,616	26
Total	905,591	1,791,118	889,060	

The 1941 sample consisted of 22,242 reports, the 1942 sample 61,103, and the 1943 sample 40,790.

Total kill figures were calculated by multiplying the average number of ducks reported per hunter on the sampled reports by the number of hunting licenses issued. The figures obtained are given in Table 7.

APPLICATION REPORTS

The duck kill by club and non-club hunters as recorded on application reports was used by Dr. Carl O. Mohr of the Illinois Natural History Survey in calculating total figures for the 1936 and 1937 seasons, and by Lewis E. Martin of the Department of Conservation for the 1938 season. The average

VARIATION IN DUCK KILL FIGURES

The kill calculations based upon acreage for the Illinois River valley—which we have every reason to believe approximates the actual kill—were respectively 1.02 times and 1.04 times as great as the figures calculated from band returns for 1941 and 1942, Tables 2, 4, and 5. The differences are relatively insignificant.

The total band return duck kill figures for Illinois, 1941–1943, were half as great as the duck kill statistics obtained from license reports (Table 7). This difference in kill data is so great as to be very significant.

While we have no duck kill statistics for comparison, it should be noted that the application report kill figures for 1936–1938 were in the aggregate 111,

551 greater than the license reports, 1,791,118 for 1941–1943. This might seem to be a small difference, but when one takes into consideration that the duck kill from 1936–1938 must have been much lower than that from 1941–1943 the disparity becomes much greater. Duck kill must have been less from 1936–1938 than from 1941–1943 because duck populations were smaller, the seasons were about half as long, and during the 1941–1943 period 72,857 more duck stamps were sold than during that for 1936–1938.

EVALUATION OF PRINCIPAL METHODS

The variation for any given year in annual kill figures obtained by various methods and from various sources makes it advisable to evaluate the reliability of methods used.

Since we believe the duck kill figures for the Illinois River valley, as calculated from the kill per acre, are the most reliable ones available, they are used as a criterion for evaluating the accuracy of other data. There is little difference between them and the data calculated from band returns for the Illinois River valley, and both are assumed to approximate the actual number of ducks killed. The band-return statistics for the Illinois River valley are probably quite accurate because of the large number of band returns and the high club kill, which furnish a sample of significant size. Kill data from other regions may be somewhat inaccurate, but they constitute such a small part of the total kill figures for the state as to have little effect upon them. A check on the state-wide accuracy of the band-return figures can be made by determining what proportion of the ducks killed in Illinois are taken in the Illinois River valley. About half the ducks shot in the state are bagged in the Illinois River valley. Doubling of the acreage kill statistics for the Illinois River valley gives state-wide kill figures of 323,700 for 1941 and 308,582 for 1942. These are much closer to the band-return figures than they are to the license report kill figures, which are so much higher that they must be far from accurate.

It is believed that exaggerated kill figures resulting from the license report system, as now employed by most states, occur for the following reasons: Few hunters keep records, and reports are made from memory perhaps a month or longer after the last hunt; not all hunters report, and most states compensate for the non-reporting hunter by assuming that his kill is the same as that of the one reporting. In most states only about 40 per cent of the license report blanks are returned, and all available information indicates that the successful hunter is more likely to report his kill than is the less successful one.

It has already been pointed out that, almost without exception, duck clubs killing the largest number of ducks are the ones that report, while clubs with a low kill tend to be haphazard about reporting. Feeney (1942) found that, while 72 per cent of the successful deer hunters reported, only about 50 per cent of the total licensed deer hunters reported.

A special questionnaire mailed by the California Division of Fish and Game to 11,000 fishermen who had failed to fill out their angling license application reports indicated (Hunter and Fry,

1940) that about half of the non-reporters had not caught anything. Gordon (1940) found from studies in Pennsylvania that " . . . those who submit their reports early are always the more successful hunters; also those who have been less successful are not likely to send in reports at all unless actually required to do so." Pennsylvania at one time received a 97 per cent return of its license reports. Other states, which make less effort to enforce game kill reporting, have a much lower rate of return, and in such states the reports are necessarily weighted in favor of the more successful hunters.

Barnes (1946) found from a follow-up questionnaire sent to a random sample of 450 license holders *who failed to return an earlier game-kill questionnaire* that 14.4 per cent showed no take of game or furbearers, whereas only 7.2 per cent of those returning the first questionnaire showed no take. This difference occurred despite the fact that in the first questionnaire a special effort was made to get the unsuccessful hunters and trappers to report, for in the introduction there is this statement: "It is just as important that we hear from the sportsmen who have *not* killed or trapped anything as from the more successful hunters and trappers."

After studying the application reports in California, Hunter and Fry (1940) stated that over 75 per cent of the deer killed were recorded by the 25 per cent of the hunters turning in their reports. They said that probably a greater proportion of the deer than of small game are reported on application reports because the hunter knows that the California Division of Fish and Game already has a record of the deer kill through the tagging system, and he has a feeling that he may be checked upon. Hunter and Fry concluded that no small game were as well recorded as deer, so that although *25 per cent of the hunters reporting* took over 75 per cent of the deer, they undoubtedly took less than 75 per cent of the small game.

The above evidence, even though of a fragmentary nature, invalidates the general assumption that the non-reporting hunter kills the same amount of game as the reporting hunter.

From a questionnaire sent to state game departments, we found that 11 of the departments have compensated for the unreported kill either by obtaining the average kill per reporting hunter and multiplying it by the number of hunting licenses sold, or by determining the reported kill and the per cent of hunters reporting and from these figures calculating the total theoretical kill. In both methods of calculation it is assumed that the hunters who did not report were as successful as the ones who did. Four states reported that they did not compensate for unreported kill; as previously stated, one of these, Pennsylvania, has in some years received 97 per cent return of its license report cards.

Perhaps a straight tabulation of license report kill, even when returns are far from 100 per cent, would yield figures more nearly accurate than where compensations are made for unreported kills. License report kill figures which are not corrected for the unreporting hunter may be, according to data in table 7, fairly similar to kill figures calculated from band returns. With 55 per cent of the license reports received in 1942, the actually reported duck kill

was very close to the figure calculated from band returns. However, with only 26 per cent returns, the license-report kill figure dropped to about half of that calculated from band returns.

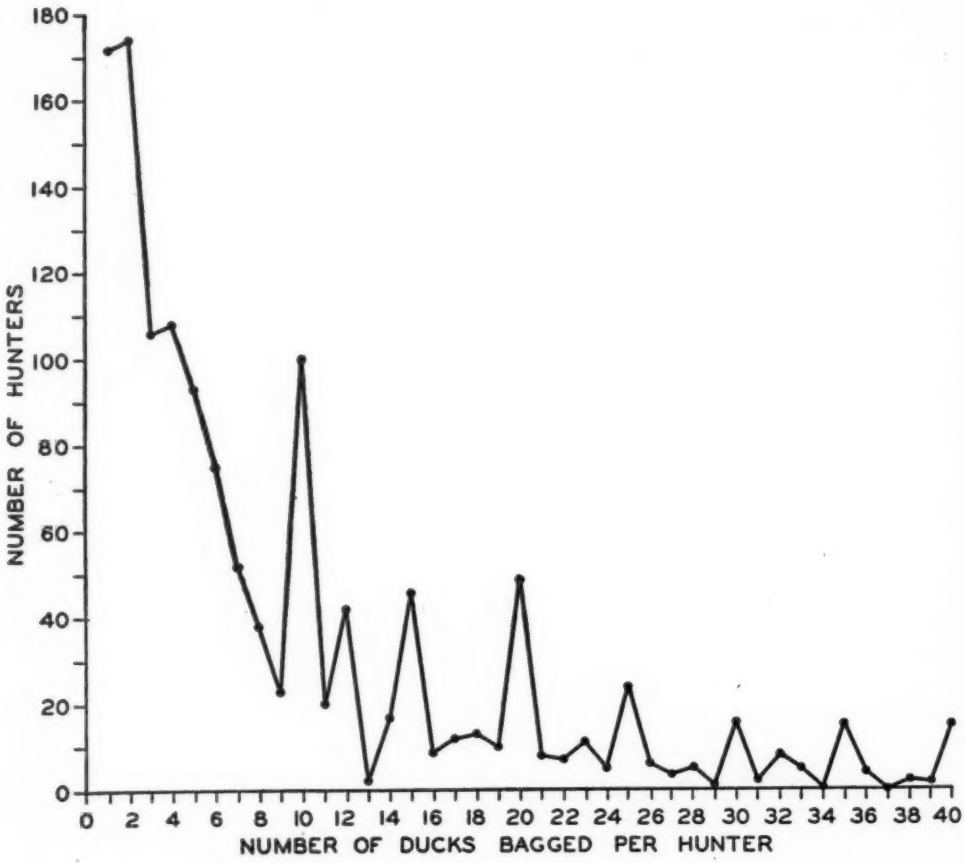

FIG. 1.—Number of ducks per hunter bagged by 1,305 Illinois duck hunters in 1943, according to license report data.

Since most states using license reports have an average of about 40 per cent returns, it would seem that their kill figures would be more nearly accurate if they did not compensate for non-reporting hunters.

It might appear that the duck kill calculated from band returns is low, since the total obtained from a direct tabulation from 75 per cent of the license reports was higher than that determined from band returns. However, other errors may affect license report systems so as to result in an upward distortion of the kill statistics.

After talking with several hundred hunters, we have found that many who kill large numbers of game animals soon lose count and, at the end of the season,

think they have killed more game than they actually have. A striking example of this was furnished by an acquaintance with whom the kill report problem had often been discussed. At the end of the 1943 season his card recorded a kill of 30 ducks. We were sure that during that season he had not killed over 12 ducks, and, when questioned, he was at a loss to account for the 30 on his card. When the reported duck kill of 1,305 hunters is plotted on a frequency basis (Fig. 1) it is evident that for most even or conveniently remembered numbers there are more reports than for the adjacent numbers. Forty-two of 1,305 hunters reported bagging one dozen ducks while only one reported taking 13. This, we think, reveals that the "human element" is an important distorting factor in the license report system.

How many hunters not only report their own kill but also that of their hunting partner? In closely scrutinizing about 2,000 kill cards we have noted that there were seven sets of two to four cards each with the same family name from the same locality; the cards in each set contained the identical kill! From personal conversations with hunters, three instances are known in which individuals recorded not only their own kill but that of their companions as well, because they were not sure just how much game they alone killed.

All of the factors that enter into producing errors in the kill statistics of the license reports system also apply to the application report system. In addition, because the data are recorded many months later—at the time of applying for a new license—memories are hazier and reports are more likely to be erroneous.

SECTIONAL DUCK KILL

The total annual Illinois duck kill figures derived from hunting license reports and those from band returns are close to agreement in indicating that about half the ducks bagged in the state are taken in the Illinois River valley (Table 8). There is wider divergence in the two groups of data for other regions of the state.

It is believed that regional duck kill percentages obtained from license reports are modified by population centers. Although the hunter is supposed to report the county in which he kills each game bird or animal an appreciable number of hunters are believed to report the kill they make outside their home county as if it were made in that county. This practice probably stems from the fact that many hunters are not sure of the counties in which they hunt. In 1942, hunters reported killing 17,984 ducks in populous Cook County. The 1941 and 1943 hunter records give similar statistics. According to Roberts Mann, Superintendent of Conservation, Forest Preserve District of Cook County, not over 7,000 ducks were taken in the county in any one year.

TABLE 8.—PER CENT OF TOTAL ILLINOIS DUCK KILL MADE IN FOUR REGIONS OF THE STATE, 1941–1943, ACCORDING TO FIGURES CALCULATED FROM BAND RETURNS AND FROM LICENSE REPORT DATA.

Region	Per cent as calculated from band returns	Per cent as calculated from report cards
Illinois River	*52.7*	*46.7*
Mississippi River	*28.2*	*22.5*
Glacial Lakes	*7.6*	*9.4*
Elsewhere	*11.5*	*21.4*
	100.0	100.0

Macon County, containing Decatur, a city of 59,305 yielded, if we are to believe license reports, a bag of 4,834 ducks in 1942. According to the state conservation officer of that county, not over 1,200 were killed there in that year. In Rock Island County, population 113,323, where 1942 license reports gave a kill of 11,884 ducks, the local state conservation officer estimated that the maximum kill there in that year was 3,000.

Peoria County, with a population of 150,000 had, according to license reports, a kill of 31,799 ducks in 1942. The writer, who is familiar with the duck hunting areas there estimates that not over 10,000 ducks were taken in the county that year.

All the evidence that we have been able to obtain indicates that counties with a large population are credited with a grossly exaggerated duck kill. Hunters from all counties mentioned in this connection, except Rock Island, undoubtedly bagged the bulk of their locally reported ducks in the Illinois River valley. Rock Island County hunters undoubtedly took most of their kill along the Mississippi River.

The distortion occasioned by hunters recording on license reports their out-of-county duck kill for their home counties resulted in reporting a higher kill in the non-waterfowl counties than actually occurs there (Table 8). Therefore, not only are the license report and related systems erroneous as to total kill but also fairly unreliable as to sectional kill.

RECOMMENDATIONS

Although the importance of measuring the annual statewide take of game birds and mammals is recognized by the conservation agencies of most states, an entirely satisfactory method of measuring this take has not yet been developed.

From information presented by Feeney (1942) that the license report deer kill figure for Florence County, Wisconsin, was about 30 per cent higher than the actual kill; from data given by Gordon (1941) that the highest possible kill of pheasants for Washtenaw County, Michigan, in 1938 was 11,600 as against the license report kill figure of 23,000; and from data presented in this study on Illinois duck kill statistics, it is evident that kill figures from most license reports, and similar systems are often so inaccurate as to be of doubtful value.

If it is as difficult as it appears to obtain accurate state-wide kill figures from the methods now in general use, it seems advisable for conservation agencies to concentrate their efforts toward obtaining more reliable kill data from sampling methods based on smaller units such as public shooting grounds, state or national forests, or cooperative land owner tracts. Reliable samples could be obtained by checking stations, or a variation as reported by Wandell (1946), or by the calendar method as discussed by Davison (1943), or perhaps by interviewing sampled hunters in various counties as advocated by Gordon (1941). Information obtained from these methods may reflect hunting success and game population changes better than other methods of measuring and recording the kill.

For annual comparative purposes or for trends in the game kill the license report system and related systems provide useful data. Furthermore figures

derived from these systems may be corrected through use of checking stations or some other similar method.

When license report returns are incomplete, it should be recognized that a larger proportion of successful hunters than unsuccessful ones have reported. If over 50 per cent returns are received from license reports, probably no compensation should be made for non-reporting hunters; our data suggest that such compensation leads to a larger error in the kill figures than if a straight tabulation is made.

Even when a large precentage of license report forms are returned, the tabulations may not give an accurate picture of the kill, because of the apparent tendency of hunters, depending upon memory, to exaggerate their kill figures.

Pennsylvania's former success in receiving a high percentage of report forms, as high as 97 per cent, resulted from strict enforcement of the law and a $2.00 fine imposed against hunters failing to report. Many other states have provisions for assessing fines against non-reporters, but make insufficient attempts to enforce such provisions.

The kill report filed at the time application is made for a hunting license is less reliable than that made following the hunting season; the application report, which covers the kill for the previous season, puts a greater strain on the memory of the reporting hunter. Also because kill data from the application reports are not received until nearly a year after the close of the current hunting season, the information is so old that some of its value is lost.

Although the questionnaire system is subject to the same basic faults that befall the license report system, it is much more economical and is much easier to initiate. Questionnaire costs are lower because of the smaller number of forms that must be printed and tabulated to achieve the same results. The Gallup Poll has amply demonstrated that an adequate cross sample, even though small, can be more accurate than a mass of data. Indiana's method of sending follow-up questionnaires to those who fail to answer the first ones, provides a correcting factor for the unsuccessful hunter who does not report as readily as the successful one. No legislative approval has been necessary to use questionnaires whereas in most states, legislative approval has been necessary to establish either the application or the license report system. In some states, legislatures have balked at putting such systems into operation; in other states, as in Pennsylvania, legislatures have discontinued such systems because of public objection. There can be little objection to the questionnaire which requests rather than demands information.

Tag or seal reports, suitable for localized areas, are probably more nearly accurate than the license, application, or questionnaire reports, for four out of seven states received almost 100 per cent returns. The reason for the high returns in four states is that the law requiring the hunter to tag and report each kill is strictly enforced; the hunter knows that wardens are likely to check the kill in the field or in transit and he complies with the law. Since kills are reported within a short time, failure of memories and tendency to exaggerate have little or no influence on reports.

Where the law requiring the hunter to tag and report the kill is not enforced, as in three states, returns average about 30 per cent. In such instances, because of the tendency of unsuccessful hunter not to report, the tag report system probably does not produce figures that are much better than the other less successful methods discussed.

Since the tag or seal system embodies marking and reporting individual game kills, this method usually is not considered practicable for most small game. However, it is probably the best method of obtaining accurate information on the kill of species in which the individual and the total kills are relatively low. Deer, wapiti, antelopes, raccoons, turkeys, and pheasants are species that are required to be tagged by some state conservation agencies.

Game warden reports are considered crude even by the three states using them. The accuracy of such reports depends largely on the individual collecting the data. If a game warden, near or soon after the close of a hunting season, would interview a large and random sample of hunters, it is conceivable that, when the average kill per hunter interviewed is multiplied by the number of licenses issued, the result might be fairly accurate. However, because the warden might sit at home and "conjure" sets of figures, because the hunter being interviewed might either fear to report a large kill or be ashamed of a small kill and accordingly "doctor" the figures, this method is open to more errors than others.

Checking-station reports undoubtedly provide the best kill information obtainable for small areas. However, since it is possible to check the kill on only localized areas, such as state and national forests, public shooting grounds, or geographically restricted sections, the resulting statistics may not be representative for an entire state.

SUMMARY

Almost every state has attempted to obtain state-wide data on game kill, and almost every state has done so by means of application reports, license reports, or questionnaires. Since return of the report forms is incomplete, practically all states have compensated for non-reporting hunter by assuming that his kill is the same as that of the reporting hunter.

Data presented in this paper reveal that this practice results in erroneously high figures because the proportion of successful hunters who report is greater than the proportion of unsuccessful ones. Furthermore, most hunters, especially those who have bagged many game animals, exaggerate their kill figures. There is also a tendency for hunters to report for their home counties game kills made in "foreign" counties.

A partial correcting factor for these errors might be obtained from local kill data, which, for example, could be collected through checking stations. Obtaining data from a sample of non-reporting hunters, as practised in Indiana, provides a possible correcting factor for differences in the kill of reporting and non-reporting hunters but not for exaggerated reported kills.

Because state-wide methods of obtaining kill data through application reports, license reports, or questionnaires are open to appreciable error, it may be more expedient for game man-

agement purposes to use checking stations, county-wide interview surveys, or special calendars—adapted for recording game kill data—to obtain pertinent game kill statistics.

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INCUBATION TEMPERATURES OF CANADA GEESE[1]

Charles W. Kossack

Barrington, Illinois

In 1944 a study of the Canada goose (*Branta c. canadensis*) on the Bright Land Farm of Mrs. A. L. Eustice near Barrington, Cook County, Illinois, was initiated by the writer and Carlton A. Beckhart.

[1] The writer wishes to acknowledge his indebtedness to Dr. Gustav Swanson, Chief, Division of Wildlife Research, Fish and Wildlife Service, Chicago, Illinois, for criticism and advice in the arrangement of the material and preparation of the manuscript; to E. E. Stevens of the Commonwealth Edison Company for suggestions regarding the use of equipment; to Margaret Kossack for suggestions and aid; to Dr. Miles D. Pirnie, Director, W. K. Kellogg Bird Sanctuary, Battle Creek, Michigan, for advice and cooperation; to Mrs. A. L. Eustice and Carlton Beckhart for whole-hearted cooperation without which this study would have been impossible.

This flock consists of 250 birds, of which approximately 25 per cent are flyers and the remainder wing-clipped or pinioned. The birds have been held under semiwild conditions, and are largely self-sustaining. Except for a very short period during the most severe winter weather, when they are fed a small amount of corn several times a week, these geese obtain their own food. They are left to themselves for feeding, mating, and nesting, and are given but little protection.

The habitat includes three bodies of water, totalling about 70 acres, with considerable aquatic plant life, both submerged and emergent. The associated land area, which is fenced, consists of about 350 acres of woodland,

hayfields, and fields of cultivated grains, chiefly corn.

All birds are number-banded, those of known age are color-banded, and mated pairs are banded with coded-color celluloid bands. All nest sites are numbered and plotted on a map, so that positive identification can be made with a minimum amount of disturbance to the birds.

During the 1945 nesting season 10 goslings were hatched in an electric incubator (Jamesway, 380-egg, still air) from 76 eggs obtained from nests that had been abandoned, flooded, or otherwise broken up. The incubator was set so that the temperature at the level of the upper surface of the eggs was 99.5°F., while that at the level of the lower surface of the eggs was 93°F., a temperature setting used successfully in the artificial hatching of mallard eggs. The low percentage of hatch of the goose eggs undoubtedly was due in large measure to the conditions to which the eggs had been subjected previous to their collection. However, because it was felt that improper incubation temperature might have been a factor, it was decided that this should be studied.

METHODS

To determine more accurately the temperatures of eggs during natural incubation under Canada geese, studies in the 1946 season were made with a Leeds and Northrop pyrometer which had been calibrated in the standardizing laboratory of a public utility company. This pyrometer had a scale reading 0° to 150°C., a switch panel, seven pairs of leads (each 150 feet long) with hot-wire thermocouples, and a cold junction in a thermos bottle of ice and water at 0°C. Additional equipment included a veterinary-type clinical thermometer and a standard mercury thermometer. (Pl. 9, A.)

Several different experiments were conducted. Observations were made from a tent blind which housed the pyrometer and switchboard. At each of the two locations where the blind was used, it was possible to reach three nests with the 150-foot leads. At each location the operator could actually see two of the nests and observe the birds' activities. The water-proofed thermocouple leads were strung above the ground to a point within 6 feet of the nest being studied; at a point 6 feet from the nest the leads were placed on the ground, covered, and brought in through the bottom of the nest. The dates of each reading are indicated in Table 1.

EXPERIMENTS TO DETERMINE TEMPERATURE

Experiment 1. In the first experiment the thermo-couple junction was cemented on the shell (point A, Fig. 1, and Pl. 9, B) of the egg, the leads going to the point of the egg so that the goose could turn it with the least difficulty and with the least possibility of tearing the wires from the egg. Junction and wires were held firmly in place with 1-inch adhesive tape applied lengthwise and at three places crosswise of the egg (point F, Pl. 9, B blackened for photographic purposes).

Experiment 2. In the second experiment a hole was drilled through the side (point B, Fig. 1) of the egg and the junction was placed $\frac{1}{4}$ inch within, piercing the membrane. The opening

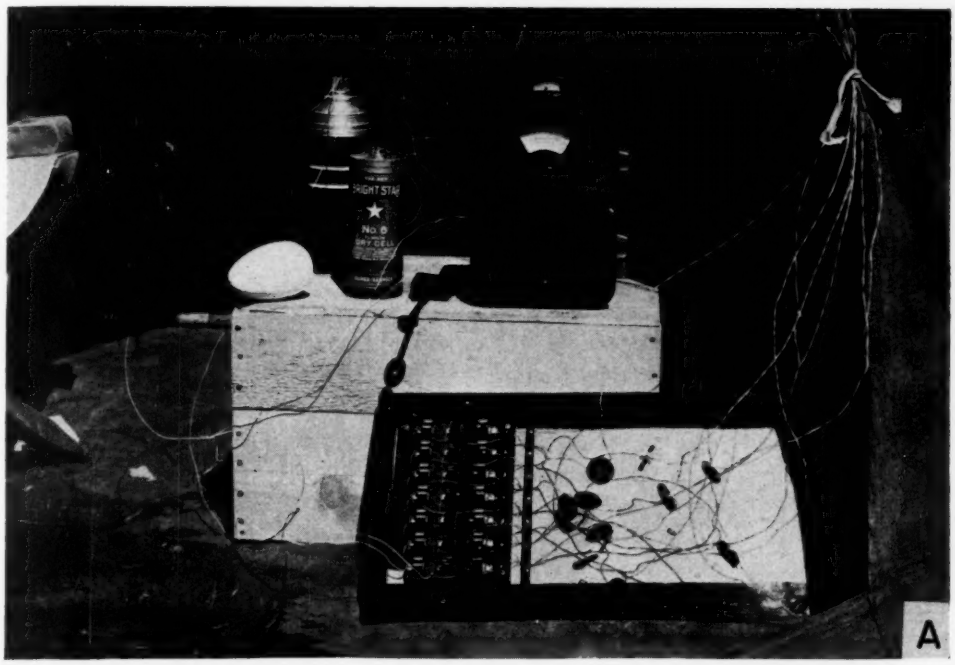

PLATE NO. A.—Equipment used in experiments: Wooden egg, pyrometer, switch panel, thermos bottle.

PLATE NO. B.—Nest No. 88 used in experiment. A, Thermo-couple on egg shell; C, Thermo-couple in egg air cell; D, Clinical thermometer in wooden egg; E, Thermo-couple on wooden egg; F, Adhesive tape blackened for photographic purposes.

was cemented shut, and the wires were fastened as in Experiment 1. This procedure was soon abandoned because of the probability that it killed the embryo.

Experiment 3. Experiment 3 was another attempt to determine the temperature within the egg. In this experiment, however, the junction was inserted through a hole drilled in the air-cell compartment (point C. Fig. 1, and Pl. 9, B), which had been located by candling with a 2-cell flashlight and outlined in pencil. At this point the junction of the thermo-couple was placed about two-thirds of the way into the air-cell of the egg without breaking the membrane. The hole was sealed with celluloid and acetone; the wire leads were run to the point of the egg and fastened as in Experiment 1.

Experiment 4. In Experiment 4, the temperatures were read from wooden eggs added to two different clutches. The wooden eggs were staked and so could not be turned on a horizontal axis. It was possible to be certain, therefore, that the temperature of the upper surface was being read, and it was thought that this would be the best means of determining the breast temperature of the incubating goose as transmitted to the egg.

For this experiment six wooden replicas of a full-sized goose egg were made, painted a dull white, and stained with tea leaves. A quarter-inch brass rod, 18 inches long, was screwed in the bottom of each egg to anchor it in the nest. At an angle of 30° from horizontal a hole was drilled through each wooden egg to hold a clinical thermometer (point D, Fig. 1, and Pl. 9, B), which would register the approximate maximum temperature. A hole was drilled through on a vertical line to permit the entrance of a thermo-couple lead (point E, Fig. 1, and Pl. 9, B) which was bent over on the top of the egg to come in contact with the breast of the goose.

These arrangements of the thermo-couples gave four points of temperature to check against each other and against the high-reading clinical thermometer. Table 1 presents the data from these nests.

RESULTS

Experiment 1. Nest No. 6. The April 7 test resulted in an average temperature of 97.8°F. for 10 readings, a low of 92.5°F. as bottom of egg temperature, and a high of 102.5°F. as top of egg temperature. The goose was on the nest for all readings.

Nest No. 22. The April 7 test resulted in an average temperature of 97.4°F. for 10 readings, a low of 90°F., when the goose was off the nest, and a low of 97.5°F. and a high of 101.9°F., when the goose was on the nest.

Nest No. 87. The May 11–17 test recorded a starting average of 98°F. for 5 readings on May 11. The temperature increased progressively (one exception, when the thermo-couple was displaced) as the embryo developed, reaching the maximum temperature of 103.7°F., the night before the embryo pipped through the shell. The temperature dropped 1.4°F. (to 102.3°F.), after the shell was pierced.

Nest No. 88. The May 11–17 test recorded a starting average of 98.1°F., for 5 readings on May 11. The temperature increased (one exception, May 12, when the goose was off the nest for two out of three readings) until the maximum of 101.9°F., was reached on May

TABLE 1.—INCUBATION TEMPERATURES IN °F. OF CANADA GOOSE EGGS AND ASSOCIATED DATA.

Date	Time	Wind	Weather	Days under incubation	Nest number	Ambient (air) temperature	(Experiment 1) Thermo-couple on egg shell	(Experiment 3) Thermo-couple in egg	(Experiment 4) Thermo-couple on wooden egg	(Experiment 4) Clinical thermom-eter in wooden egg	Reference key
4/ 7	(Av. of 10) readings)	SE	O	5	6	46.1	97.8		98.1	103.3*	A
4/ 7	(Av. of 10)	SE	O	2	22	46.1	97.4			101.9	B
4/ 7	(Av. of 10)	SE	O	1	33	46.1			99.99	101.7	B
5/11	(Av. of 5)	N	C	15	88	49.7	98.1	98.7	99.1	102	C
5/12	(Av. of 3)	NW	C	16	88	47.9	93.4*	92.7*	90 *	101.2	D
5/13	7:30 P.M.	S	O	17	88	56.7	99.2	102	91.7*	101.8	E
5/14	7:15 P.M.	S	C	18	88	64.7	101.7	102.7	102.7	101.6	
5/15	7:30 P.M.	N	R	19	88	55.3	101.7	100.2	102	101.6	
5/16	7:30 P.M.	SE	C	20	88	51.3	100.7	101.9	101.7	101.6	
5/17	7:15 P.M.	NE	O	21	88	51.7	101.9	100.2	100.9	101.4	
5/11	(Av. of 5)	N	C	19	87	49.7	98	98.2	102.6	101.4	C
5/12	(Av. of 3)	NW	C	20	87	47.9	95.5*	101.9	101	101.4	D′
5/13	7:30 P.M.	S	O	21	87	56.7	100.3	102.3	101.2	101	
5/14	7:15 P.M.	S	C	22	87	64.7	102	101.7	101.7	101.6	
5/15	7:30 P.M.	N	R	23	87	55.3	102	100.7	102.3	101	
5/16	7:30 P.M.	SE	C	24	87	51.3	103.7	103.5	101.7	100.8	
5/17	7:15 P.M.	NE	O	25	87	51.7	102.3	102.3	101	101.6	F
Averages							100.4	101.3	101.1	101.5	

* Omitted when averages were computed, see reference key.

Weather: O—Overcast C—Clear R—Rain.

A —Figures are average of 10 readings taken during the entire day. Clinical thermometer reading of 103.3 was due to the fact that the tip of the thermometer was protruding one-fourth inch beyond the outside of the wooden egg.

B —Figures are average of 10 readings taken during the entire day. Clinical thermometer readings were obtained by having the tip of the thermometer $\frac{1}{8}$ inch beyond the outside of the wooden egg. This method was used in all later readings.

C —Average of 5 readings taken during the entire day.

D —Average of 3 readings. Low figure is due to the fact that the female was off the nest for 2 of the readings.

D′—Thermo-couple off the egg shell, causing reading of 95.5. Nest temperature?

E —Figure of 91.7 was caused by the wooden egg being broken off the stake, the thermo-couple being pushed down and to the outside of the nest.

F —Note temperature drop. Eggs pipped, opening about the size of a dime.

17, when the test was discontinued. These eggs had been under incubation for 21 days.

Nest No. 86. This nest was deserted 12 hours after the thermo-couple was placed on the egg. One reading was recorded: 76°F., the egg was shell cold to the hand and the ambient temperature 49.7°F., evidently indicating that the live embryo was dissipating enough heat through the shell to result in the higher temperature reading. This clutch consisted of four eggs pipped in the cracked stage. The thermo-couple and tape were removed from the eggs. In so doing, a part of the shell was torn off and the membrane of one egg broken. These eggs were placed in an incubator at the temperatures previously mentioned, a piece of wet cloth put over the egg that was damaged. The next morning three of the eggs, including the damaged one, hatched; the fourth died after pipping through the shell.

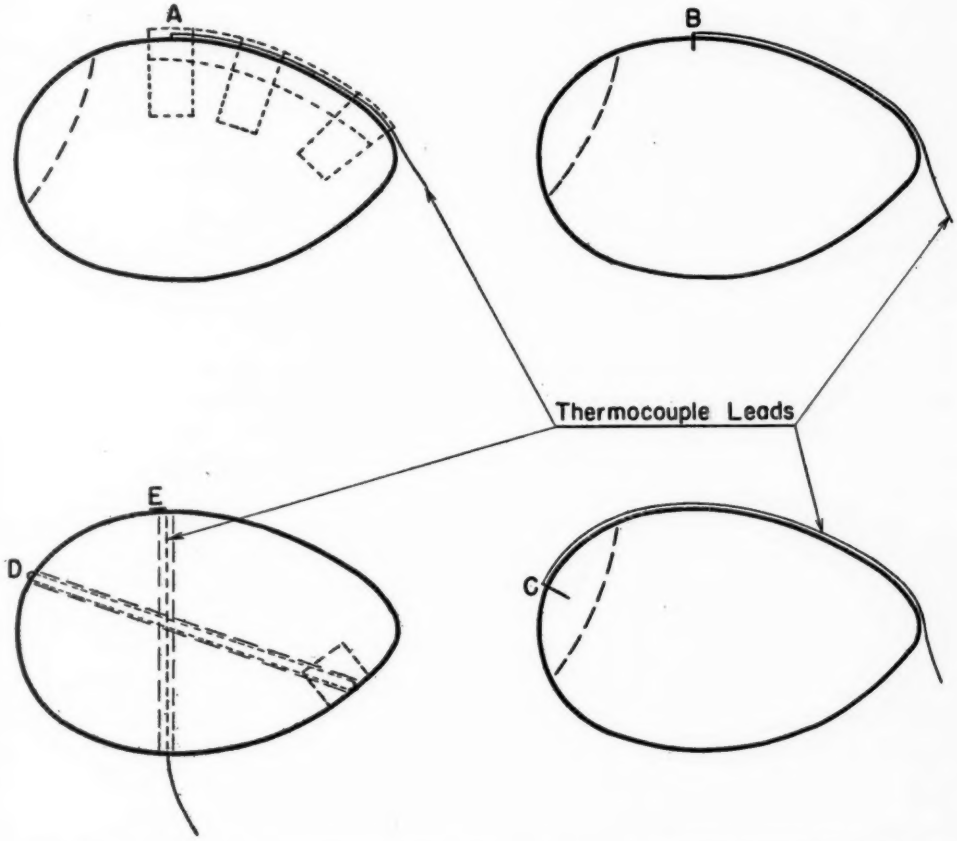

FIG. 1.—Positions of temperature recording apparatus. A. Thermo-couple on egg shell. B. Thermo-couple in egg. C. Thermo-couple in egg air cell. D. Clinical thermometer in wooden egg. E. Thermo-couple on wooden egg.

F —Note temperature drop. Eggs pipped, opening about the size of a dime.
side of the nest.

The maximum variation in the top and bottom temperatures of the egg shell while the goose was on the nest, was 10°F. This variation occurred in only one instance, when that part of the egg bearing the thermo-couple rested on the nest bottom or ground. Two showed 7°F., difference. The average variation was 3°F. The average temperature for all nests was 100.4°F.

Experiment 2. Nest No. 6. The April test recorded an average temperature of 93.7°F., for 10 readings when the eggs had been incubated for 5 days. Low temperature recorded was 88.7°F. high, 95.7°F. Because several eggs of this clutch disappeared on the day of hatching, it is not known whether this egg hatched. This disposition of the thermo-couple was discarded; a more satisfactory placement was used in the later tests identified as Experiment 3.

Experiment 3. Nest No. 87. The May 11–17 test resulted in an average temperature of 98.2°F., for 5 readings on May 11. Temperatures increased until the maximum of 103.5°F., was reached on May 16, the day before the eggs were pipped open. The minimum temperature recorded was 96.7°F.

On the night of May 17, examination of the eggs having junctions placed as in Experiments 1 and 3 in Nest No. 87, revealed that each of the embryos had pipped a hole the size of a dime beside the adhesive tape holding the wires on the eggs. Later that evening the adhesive tape was removed from the eggs under experiment. This nest had a clutch of five eggs, and on the following morning all had hatched. Even though one of the eggs had been drilled and the thermo-couple junction inserted into its air-cell compartment 7 days previously, there was no interference with normal hatching.

Nest No. 88. The May 11–17 test started with an average temperature of 98.7°F., for 5 readings on May 11. The maximum of 102.7°F., was recorded on May 13; the minimum was 93.7°F. The test was discontinued after 21 days of incubation.

The average temperature for all nests was 101.3°F.

Experiment 4. The thermo-couple on top of the wooden egg produced the average temperature of 101.1°F., for 40 readings, a maximum of 102.7°F., and a minimum of 98.1°F. The readings of 90°F., and 91.7°F., were not normal and have been omitted from averages. See reference key, Table 1.

The clinical thermometer recorded an average maximum temperature of 101.5°F., for 16 readings, the highest maximum recording 102°F., and the lowext maximum recording 100.8°F. In each instance the thermometer recorded the maximum over a 24-hour period. The recording of 103.3°F., for Nest No. 6 on April 7 was omitted from the averages because the tip of the thermometer protruded farther from the egg than in the other tests

BODY TEMPERATURES

A few body temperatures were taken with a veterinary thermometer which read to 110°F. The incubating birds were difficult to capture; some of them defended their nests with violent attacks on the intruder. The others (non-breeders and post-incubators) were driven into a pen and handled without much excitement. The temperatures of the two incubating birds were lower than those of non-breeding birds and

birds that were through incubating. The readings (cloacal temperatures) thus obtained are presented in Table 2.

TABLE 2.—CLOACAL TEMPERATURES OF CANADA GEESE.

Bird	Temperature (°F)	Respiration per minute over 5-minute period
Incubating birds		
Female No. 666	105.2	18
Female No. 899	106.	11
After incubation		
Female No. 712	108.4	19
Female No. 685	108.4	20
Female No. 685	106.6 (2 days later)	21
Male No. 688	106.9	21
Non-breeders		
Male No. 867	107.1	12
Male No. 870	108.4	15
Male No. 870	107.6	14
Male No. 870	107.3	13
Female No. 661	107.	19
Female No. 728	109.2	15
Female No. 728	108.7	13
Female No. 728	108.4	12

ARTIFICIAL INCUBATION

In the 1946 season 16 goslings were hatched in an incubator from 38 eggs collected from deserted nests and from those scattered at random before the beginning of nesting. The incubator was set so that the temperature at the top was 99.5°F., at bottom 93°F. (as in 1945), the center 96° to 96.5°F. The humidity was 65 per cent. After the eggs were pipped open, the goslings emerged quickly and were active. The time for incubation was 31 days.

NATURAL INCUBATION PERIOD

Of 22 nests for which dates of laying were known, one hatched in 25 days, 17 in 26 days, one in 26 to 27 days, two in 27 days, and one in 28 days. The normal incubation period appears to be 26 days plus or minus one or two days.

MISCELLANEOUS BEHAVIOR

In the course of this study several additional facts were revealed. When the wooden egg with the thermocouple and wires attached thereon was removed from Nest No. 6 (Experiment 4) after being in use for 24 hours, five full turns of wire were found wrapped around the stake attached to the egg. This wrapping of the wire indicated that though the bird had been unable to roll the egg to turn it, the bird had evidently turned the egg from end to end at least 10 times in 24 hours. After this condition was noted, several observations were made on incubating birds. It was found that birds work on the eggs and nest at about 50-minute intervals with the following procedure: the bird stands up in the nest, turns 150° to 180°, rolls the eggs under the front part of its body, sits down, settles into position, and replaces disturbed nest material. At the end of another period these actions are repeated. This procedure was watched on two different days for periods of two to three hours each; six nests were observed.

On two occasions an incubating female goose was observed to stand up in its nest, step over the side, and (without covering the eggs) begin to pick up nest-building material within reach. The bird passed this material back as far as the neck and head would reach on both right and left sides without turning the body. After working out for a distance of 15 or 20 feet, the bird returned to the nest and placed upon it the material that was within reach.

When this had been repeated two or three times in one direction, a new one was taken, and thus three or four paths were formed. Then the bird returned and settled down in her nest.

SUMMARY AND CONCLUSIONS

Methods were devised to obtain the temperatures of the top and bottom surfaces of Canada goose eggs during incubation, the temperature of the developing embryo, the temperature of the breast of the incubating bird, and the maximum temperature reached in the nest at any time while the bird was on its nest. In one instance the thermocouple junction was in the air-cell compartment of the egg when the embryo pipped through the shell. The experiments were conducted with a flock of semiwild birds, the body temperatures of which, it is believed, should be similar to those in the wild.

From this study it has been found that the average incubation temperature of the embryo is 101.3°F., the average shell temperature 100.4°F., the average breast temperature of the incubating goose 101.1°F., the average maximum temperature reached in the nest 101.5°F., and the usual incubation period 26 days.

The fact that the incubation period was 5 days longer for eggs in a machine than for eggs under a goose, indicates that the incubator top temperature of 99.5°F., is subnormal and should be raised at least 1.5 to 2 degrees.

The temperature rises with the development of the embryo.

There is a slight variation in temperature among various birds.

The construction of the nest is a vital factor in the variation between top and bottom temperatures of eggs because of the amount of heat that is dissipated into the ground or nesting material on the underside of the egg.

THE WILD TURKEY IN LOUISIANA[1]

George H. Bick
New Orleans, Louisiana

Field investigations on the status of the eastern wild turkey) *Meleagris gallopavo silvestris*) in Louisiana were carried on under Louisiana Pittman-Robertson Project 3-R from June 1941 to October 1942; the project was then discontinued but resumed in June 1946.

No comprehensive Louisiana studies have been made; literature references are brief and, for the most part, simply record the bird from the state or from local areas and repeat generalized statements from the classical literature relative to habitat and habits.

Perhaps the earliest record of turkeys is that of Du Pratz (1758) who gave an account of hunting them, and of the utility of feathers in preparation of

[1] Contribution from Pittman-Robertson Wildlife Research Project 3-R of the Louisiana Department of Wild Life and Fisheries. All figures were drawn by George H. Penn who also assisted in preparing the manuscript.

ornaments by the Indians. Schultz (1810, quoted by Wright, 1915) included the turkey in a list of birds native to the New Orleans area. Joutel's (1846) account of the last voyage by LaSalle contains frequent references to the abundance of turkeys and their utilization for food. Some of Joutel's records doubtless pertain to what is now Louisiana, but exact localities can scarcely be determined.

Beyer (1900) listed *Meleagris gallopavo fera* as resident and breeding in many sections of the state. Kopman (1907) reported it as "a resident species of southeastern. . . . Louisiana . . . absent from the delta region." Beyer, *et al.* (1908) recorded turkeys as commonest in the piney sections but absent from the typical fertile alluvial section of the southeast. McIlhenny (1914) gave an extended general account of the species based on the notes of Charles Jordan, Manager of the Morris Game Preserve near Hammond.

HUNTING REGULATIONS

It is impossible to trace population trends for the past, since kill reports have never been required by the state. The only numerical estimate available is that of McIlhenny (1934) who reported the state kill for the season 1909–10 to have been 2,219 birds. Thereafter only general statements are available. Alexander (1918) stated "there has been a very perceptible increase in the wild turkey that at one time promised to be exterminated." Holmes (1922) reported that the birds were "at least stationary in numbers in most localities . . . and in a few instances they were reported as increasing." Daspit (1930) recorded them as "becoming more plentiful . . . due to the vast areas of cut over land that have been allowed to grow in thick underbrush." A striking contrast was noted by Cope (1932), who stated "today the turkey is facing extinction."

As early as 1902 there was a state closed season. Figure 1 outlines the changes from that time to the present. From 1920 to 1932 there was a spring hunting season on both hens and gobblers. The season was closed completely for the entire state from 1933 to 1945, and then opened on gobblers only during the first 15 days of April.

The first bag limit was established in 1905 when it was legal to kill 25 birds a day, but with no seasonal limit. This situation continued until 1911, when the daily legal bag was reduced to one bird. In 1924 the first seasonal limit was established at 12; this was further reduced to five in 1927; and the limit now is one for the season.

The shooting season received considerable discussion in reports of the Conservation Department for the years 1918–21, and but little thereafter. Holmes (1920) stated "the present season . . . is in need of revision . . . the month of March at least should be excluded from the turkey season." Kopman (1921) stated "the special provision postponing the commencement of the closed season to April 1 is a feature of doubtful value. . . . "

In 1927 an act of the state legislature gave individual parishes the right to declare local closed seasons. By 1929 the turkey population was so low that 14 parishes applied for local closed seasons. This local concern was inconsistent with the optimistic views in various reports of the Conservation Depart-

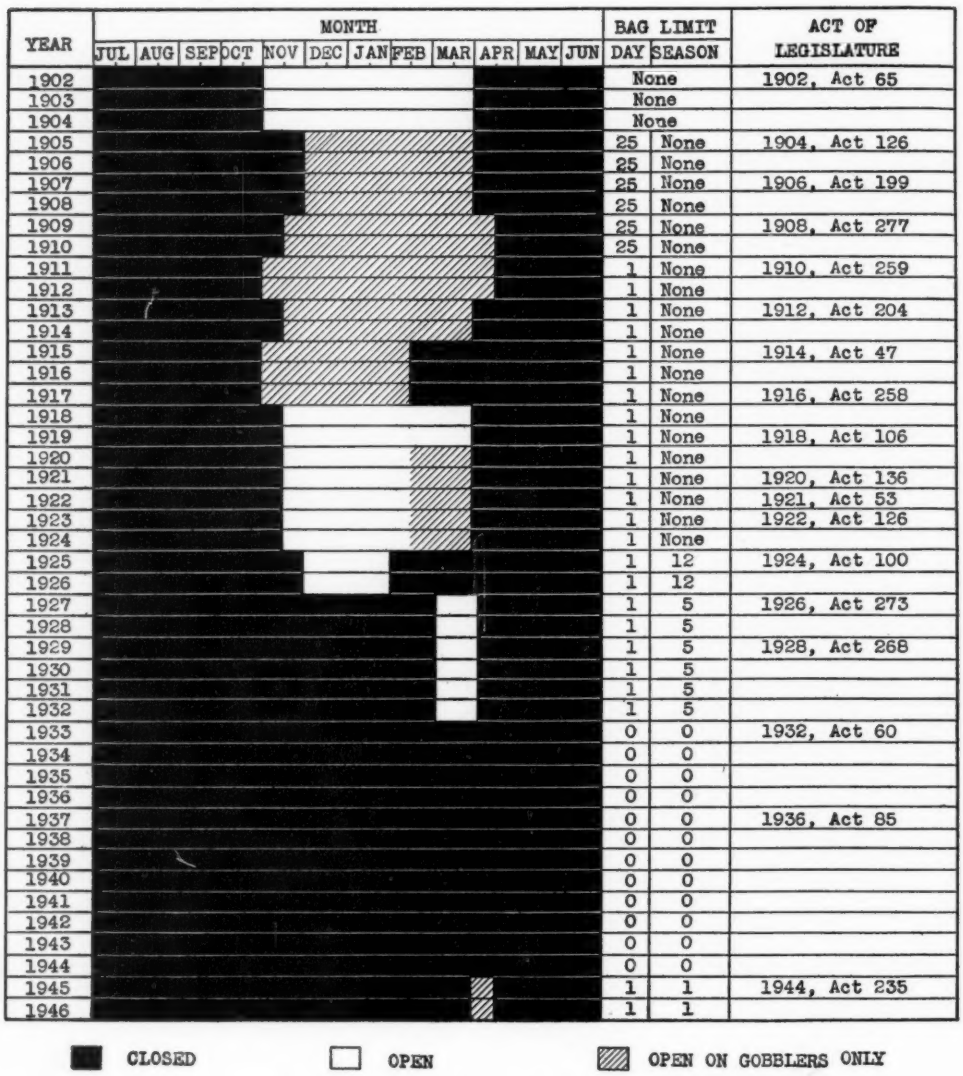

FIG. 1.—The Wild Turkey Season in Louisiana, 1906–1946.

ment for the same period.

Records of violations are available only from 1940 to date; a total of three have been recorded, all during 1945 from Madison Parish.

INVENTORY

To obtain basic data for future management, a statewide inventory was conducted from June 1941 to October 1942 by mailing questionnaires to all conservation agents, the state forestry staff, each local wildlife federation, and certain local officials selected at random. The following information was requested:

1. What is the status of the turkey locally (abundant, common, scarce, absent).

2. Have the birds ever been personally observed? How many? Where? When?
3. What do you think is the extent of illegal kill?

Of the 650 copies mailed, a 70 per cent return was obtained. This high return presumably did not indicate a correspondingly strong interest in the project but was attributed in a large measure to the many state employees who considered the answering as a job requirement. It was significant that the lowest return was from the sportsmen's clubs.

The following general information was received:

1. Nearly everyone considered the turkey to be scarce or absent.

2. Actual personal observation was rarely reported. If personally seen the flock size was seldom noted and the date of the record scarcely ever given.

3. Specific information regarding the extent of illegal kill was almost entirely absent.

4. No demand or suggestion that the season be opened was received but pleas for more vigorous enforcement of the closed season were numerous.

5. A general interest in wild turkey restoration was manifest but the consensus was always that the local range was excellent and should be restocked.

Thus basic information was obtained

TABLE 1.—LATEST RECORDS FROM PARISHES IN ORIGINAL RANGE, BASED ON QUESTIONNAIRE.

Parish	Place	Date	Number	Observer
Beauregard	Northeast of Meryville	1940	6	Chuyler Gill
Bienville	Saline Swamp	1932	1	J. S. Campbell*
Bossier	Southern part	1935	?	G. H. Lowery*
Calcasieu	Hickory Creek	1939	4	W. A. K. Seale
Claiborne	Corney Bayou, and D'Arbonne Bayou	1906–11	?	J. N. Brown
Catahoula	West of Harrisonburg	1940	3, 22	L. L. McGuffee
Concordia	Eva	1916	2	T. H. Forman, Jr.
DeSoto	Northeast, near Red River	1936	?	G. H. Harris, Jr.
East Carroll	Northwest part	1941	7	C. A. Rose
Evangeline	Boggy Bayou (Beaver)	1941	8–10	E. A. Butler
	Chicot State Park	1940	12(2)	W. R. Vailot
Grant	Iatt Lake	1937	5	B. H. Lemoine
Jackson	East of Chatham	1941	1	T. H. Kilpatrick
Lincoln	Northeast part at Lawrences' ferry	1941	1	Jos. Singer
Natchitoches	Near Campti	1932?	3	Conrad Williams
Ouachita	Southwest corner	1940	1	J. L. Frost
Richland	Lafourche Swamp	1940	?	M. B. Cooper
Sabine	Near Pleasant Hill	1939	2	W. D. Davis, Jr.
St. Landry	Northwest Corner	1912	3	A. Deshotels
Tangipahoa	Near Husser	1940	3	Recy Husser
Vernon	Anacoco Bayou (Anacoco)	1938	8–10	H. B. Marcus
Webster	Clarks' Bayou (Minden)	1925	18–20	J. E. Long
West Carroll	Boeuf River	1936	?	Allan Hawsey
West Feliciana	Northeast corner	1938?	2–3	T. H. Martin
		Average:	6	

* Oberholser (1938).

as to the parishes to be checked by more careful methods. This was essentially that of Mosby (1941) and consisted of plotting flock locations by cross checking various local reports furnished and Calcasieu bordering Texas were not visited and their status is based solely on the questionnaire.

Because in so many areas of former abundance the turkey had been reduced to a critical low, there was a marked tendency for local citizes to insist that the birds were still present in their parishes even though none had been seen for many years. The basic reply was always that the neighbor had recently seen or heard them. At times a

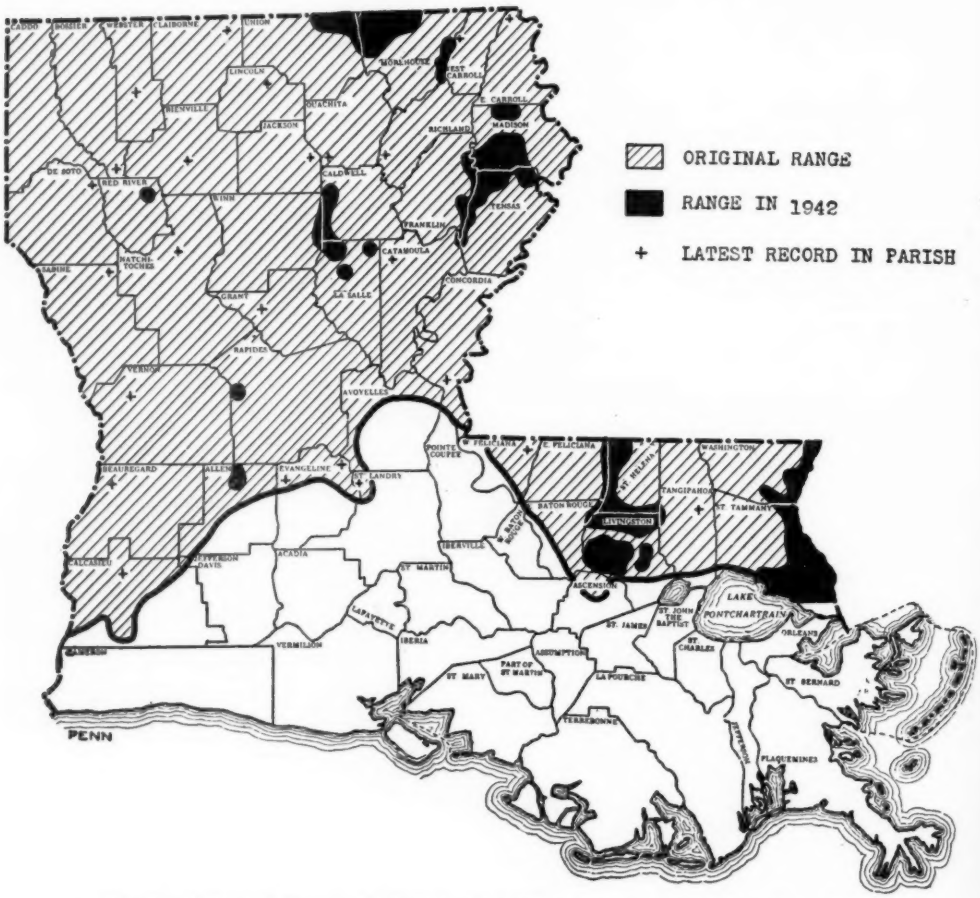

FIG. 2.—Original Range, Definitely Established Range, and Locality of the Most Recent Records in the Doubtful Range.

by individuals living in immediate contact with the turkey range.

An endeavor was made to locate all flocks in those parishes where the questionnaire indicated a reasonable possibility of their presence. However, the parishes of Sabine, Vernon, Beauregard,

day's travel of many miles in these areas yielded no specific information on recent observations.

Original range. From the literature and the questionnaire it was possible to obtain a fairly accurate idea of the original range. This occurred in two large blocks as shown in Figure 2 and constituted: (1) all of the state east of the Mississippi and north of Lake Pontchartrain, (2) that portion north of an irregular line drawn from the northwestern corner of West Feliciana to the southwestern corner of Calcasieu Parish. This area comprised 40 parishes and approximately 28,000 square miles.

Primary factors which undoubtedly limited the original range were the presence of prairie vegetation in the Southwest and the extensive areas of cypress-tupelo swamps in the South which were periodically flooded.

All parishes in which turkeys have been recorded in the literature are listed below. These include 38 of the 64 parishes and comprise nearly all of the northern two thirds of the state as well as the entire portion north of Lake Pontchartrain and east of the Mississippi.

Allen: Daspit (1930)[2]
Beauregard: Daspit (1930)
Bienville: Daspit (1930), Viosca (1933), Oberholser (1938)
Bossier: Viosca (1933), Oberholser (1938)
Caddo: Viosca (1933)
Calcasieu: Daspit (1930), Viosca (1933)
Caldwell: Viosca (1933)
Catahoula: Viosca (1933)
Concordia: Arthur (1928,[2] 1931), Oberholser (1938)
DeSoto: Daspit (1930)
East Baton Rouge: Viosca (1933)
East Carroll: Arthur (1931), Sonderegger (1932), Viosca (1933) Oberholser (1938)
East Feliciana: Viosca (1933)
Franklin: Viosca (1933)
Grant: Arthur (1928)
Jackson: Daspit (1930), Viosca (1933), Oberholser (1938)
LaSalle: Viosca (1933)
Lincoln: Viosca (1933)
Livingston: Viosca (1933)
Madison: Arthur (1928), Daspit (1930), Arthur (1931), Sonderegger (1932), Viosca (1933), Campbell et al. (1934), Oberholser (1938), Bick (1942)
Morehouse: Sonderegger (1932), Viosca (1933)
Natchitoches: Dorman (1926), Viosca (1933)
Ouachita: Viosca (1933)
Rapides: Daspit (1930), Viosca (1933)
Richland: Sonderegger (1932), Viosca (1933), Oberholser (1938)
Sabine: Daspit (1930), Viosca (1933)
St. Helena: Sonderegger (1932), Viosca (1933)
St. Mary: Oberholser (1938)
St. Tammany: Cope (1932), Sonderegger (1932), Viosca (1933)
Tangipahoa: Arthur (1918), Sonderegger (1933), Viosca (1933)
Tensas: Arthur (1928, 1931), Viosca (1933), Oberholser (1938)
Union: Sonderegger (1932), Viosca (1933), Oberholser (1938)
Vernon: Dorman (1926), Daspit (1930), Viosca (1933)
Washington: Viosca (1933)
Webster: Viosca (1933)
West Carroll: Sonderegger (1932), Viosca (1933)
West Feliciana: Viosca (1933), Oberholser (1938)
Winn: Arthur (1928), Sonderegger (1932), Viosca (1933), Oberholser (1938)

[2] Based on the parish having filed application for a local closed season.

No published records were available for the remaining parishes, nearly all of which are in the southern third of the state.

No definite information was obtained that St Mary Parish should be included in the original range. Presence was defi-

nitely established for Red River and Evangeline Parishes. No information on observations in Caddo and Avoyelles parishes was received. However, the former was quite clearly in the original range and we have judged that the northern portion of Avoyelles may once have been occupied.

There are three specimens in the Louisiana State University Museum of Zoology taken near Holden in Livingston Parish. In the Louisiana State Musuem are two specimens from Holden, one from Avery Island in Iberia Parish, and in the collection of the Conservation Department a fourth from Tallulah in Madison Parish. There is a specimen in the Colorado Museum of Natural History which Oberholser (1938) listed from St Mary Parish, but the only information available from the Colorado Museum was that the specimen was obtained in Louisiana.

Doubtful range. Table 1 lists the latest reliable record for those parishes within the original range where flock presence could not be definitely established. Some of the observations were quite recent and definitely stated but either they were the sole record from the parish or the reports were contradictory. As such, presence in all these parishes must be considered doubtful. A few of the records show that turkeys disappeared long ago but in many parishes the observation is recent and for these there is every reasonable possibility that the turkey persists. The parishes of Sabine, Vernon, Beauregard, Calcasieu are all included as doubtful, but Newman (1945) reported 125 birds in 1943 on the Devil's Pocket Refuge in Newton County, East Texas. This population was built up from native stock ranging the same general area.

Definite range. Reasonably definite presence was established for 17 parishes. This information is summarized in Table 2 and in Figure 2. The occupied range consisted of rather small, sharply limited and widely separated units, and comprised a total area of 1,320 square miles or approximately five per cent of the original range.

The only significant population on unprotected areas was in the Livingston-St Helena area and in the Pearl River bottomlands of St. Tammany and Washington Parishes.

On protected areas a large population was recorded from the Singer-Ayer Refuge in Madison and Tensas Parishes and a smaller one from the Morehouse Game Refuge in Morehouse and Union Parishes.

It was estimated that there were 158 flocks in the State. Observations by the author (1942) on the Singer Refuge indicated that the average flock size was 11, and this would give a theoretical total state population of 1,738 birds. The average flock size as noted in Table 1, which represents isolated and dwindling remnants, was only six. However, the present estimate of the number of flocks is conservative and it is felt that the total number of birds is minimized.

Comparison of these data with those available from other states where comprehensive studies have been made are enlightening. In Virginia, Mosby (1941) found that the total population was 2,020 flocks. Leopold and Dalke (1943) found the 1942 population in Missouri to be 596 flocks. If flocks were of approximately equal size it appears that the Louisiana population is at a critical low.

GENERAL CHARACTER OF OCCUPIED RANGE

According to the 1940 census 16 million acres or 29 per cent of the state land area is in forests. Roughly one million acres or 6 per cent of this area is in occupied turkey range. The major forest types for the state are given in Figure 3.

In general, a significant population was correlated with large unbroken blocks of forest. Livingston Parish was exceptional in presenting a high degree of interspersion of scrub forest interrupted by numerous small farms in the crude cultivation stage.

Approximately 123 flocks, or 78 per cent of the population, were restricted to areas in bottomland hardwoods. The only exception was in the general area of the junction of Livingston, St Helena East Feliciana, and East Baton Rouge Parishes where several forest types merge into an interesting mixture of pine and hardwood.

Occupied areas typically contained an abundance of mast producing trees. Several oaks (*Quercus spp.*) sweet gum (*Liquidamber styraciflua*) and a variety of berry producing shrubs and vines such as *Vitis, Crataegus, Cornus,* and *Smilax* seemed more or less characteristic. Leguminous plants were never abundant.

Significant turkey populations were associated with a low human farm population. The 1940 census gave the average rural farm population density for the state as approximately 30 persons per square mile whereas the average for the occupied parishes was 18. On the other hand, the average size of the farm (66 acres) and the average per cent of the parish in cultivation (35 per cent) was identical for occupied parishes and for the state average.

Forty two per cent of the total turkey population occurred on or just adjacent to protected areas. The Singer-Ayer Refuge (Figure 4) an area of approxi-

TABLE 2.—DEFINITELY ESTABLISHED FLOCKS, ESTIMATED OCCUPIED RANGE, AND RELATIVE DENSITY.

Parish	Sq. mi. in ph.	Occupied range sq. mi.	Occupied range % in ph.	Flocks in parish	Sq. miles per flock
Madison	650	259	*40*	45	6
St. Tammany	906	176	*19*	27	6
Livingston	662	240	*36*	23	10
Morehouse	831	152	*18*	14	11
Washington	665	84	*13*	12	7
St. Helena	420	64	*15*	9	7
Tensas	632	88	*14*	7	12
Franklin	630	49	*8*	4	12
Union	918	37	*4*	3	12
Red River	400	36	*9*	3	12
LaSalle	640	37	*6*	3	12
Allen	632	25	*5*	2	12
Caldwell	531	25	*5*	2	12
Winn	969	12	*1*	1	12
Rapides	1370	12	*1*	1	12
East B. Rouge	455	12	*3*	1	12
East Feliciana	464	12	*3*	1	12
State total:		1320		158	

mately 125,000 acres in Madison and Tensas Parishes supported a minimum of 56 flocks. This area has been closed to hunting since 1926 but no other management steps were even undertaken. The Morehouse Game Refuge (Figure 4) an area of 118,000 acres along the Morehouse-Union Parish line contained 17 flocks. This refuge has been closed to hunting since 1940. The lands of the Urania Lumber Company located at the juncture of Winn, Caldwell, and LaSalle Parishes have long received some measure of protection, and supported an estimated four flocks. The main factor accounting for populations in these areas is an extensive well isolated wilderness where some measure of protection has long been provided.

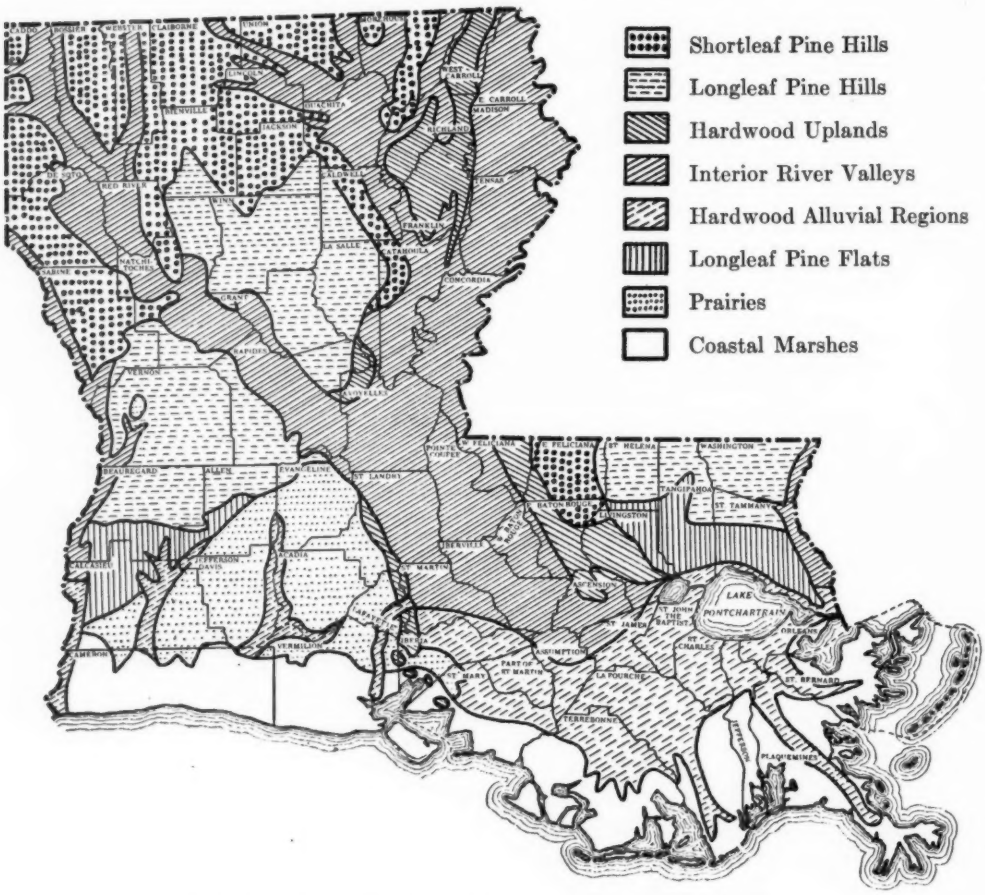

FIG. 3.—Major Physiographic Areas (after Viosca, 1933).

MANAGEMENT

Occupied range. The three upland refuges (Figure 4) in the state, in private ownership but under lease to the Conservation Department, all support a considerable turkey population. State-

FIG. 4.—Possible Sites for Refuge or Management Areas.

1. Singer-Ayer State Game Refuge
2. Morehouse State Game Refuge
3. Lake Bistineau State Game Refuge
4. Chicot State Park
5. Fontainbleau State Park
6. Sam Houston State Park
7. Chemin-a-Haut State Park
8. Woodworth State Forest
9. Catahoula Division, Kisatchie National Forest
10. Kisatchie Division, Kisatchie National Forest
11. Evangeline Division, Kisatchie National Forest
12. Vernon Division, Kisatchie National Forest

wide restoration depends to a considerable extent upon the utilization of these birds in repopulating depleted areas.

The Singer-Ayer Refuge is actually a continuous tract and for practical purposes may be considered as a unit. This tract originally constituted approximately 125,000 acres. The Singer lease will expire October 1946 and this will deduct 80,000 acres. Presumably the Ayer agreement for the other acreage will continue. Logging of the original Singer tract is now practically completed. Much of this acreage has been

sold in small tracts and is being developed as farm land. Because every effort to purchase portions by the state has failed it appears that the turkeys here should be trapped and placed on state or federal owned land where they can be actively protected and managed. Some degree of management of the Ayer Refuge should be effected. However, because of the high agricultural worth of this area it can not be considered as a permanent management area unless purchase (which has been impossible in the past) can be accomplished.

The Morehouse Game Refuge was originally 118,000 acreas but has recently been reduced to 43,000. Possibilities for management are good but many problems must be overcome. The land is of low agricultural value and will likely persist as a refuge. However, most of the tract is included in the Monroe gas field and is thus subject to considerable disturbance. It is accordingly doubtful if entirely satisfactory management could be accomplished. A complete inventory is needed of all game and predatory species. Hogs and cattle must be eliminated and the concept of management substituted for that of inviolate sanctuary. Detailed management plans must be formulated. Local residents should be made aware of the purpose and the method of operation of the refuge and efforts made to obtain their active support. The area requires a game manager rather than a warden.

On state owned land one flock was recorded from the Fontainbleau State Park in St. Tammany Parish (Figure 4) and others ranged in the vicinity. This area is too generally used for recreation to be of primary importance in turkey restoration. However, turkey requirements should be considered in the development of the park and efforts made to maintain it in a primitive condition.

The 6,000 acre Chicot State Park in Evangeline Parish is in a more isolated area and is surrounded by suitable range. Possibilities for restoration here are excellent and steps have been taken in this direction. Fifty birds six-weeks old, obtained from Mississippi, were released here in October 1945 and the majority survived the first winter (Wells, 1945). It is again desirable that steps be taken to acquaint local residents with the purpose and method of operation of the park to obtain their support, and that human disturbance be minimized.

The Woodworth State Forest in Rapides Parish, an area of 6,000 acres, offers possibility but it is surrounded by unsuitable cut-over pineland.

The creation of managed refuge areas is urged for the following localities:

1. The area at the juncture of LaSalle, Caldwell, and Winn Parishes owned by the Urania Lumber Company constituting approximately 75,000 acres of suitable range but with a turkey population now at a critical low. Several sizeable hog and cattle proof enclosures were existent and the area was privately posted against hunting. This company is noted for its pioneer work in forest conservation and at the time of the present study the area was available in whole or part for refuge or management projects.

2. The West Bay Area in Allen Parish, a tract of approximately 36,000 acres constituting an isolated unit surrounded by unsuitable range. The turkey population is at a critical low. An active local interest in the establishment of a protected area is manifest.

3. The northern part of Livingston Parish. This is in the center of an extensive area of occupied range. It is readily accessible to some of the larger centers of human popula-

tion and every indication is that an illegal kill has always been high.

4. The Pearl River bottomlands in St. Tammany and Washington Parishes. This is an extensive wilderness area and with the cutting of the Singer tract is the last area of the type in the state. It is readily accessible to the city of New Orleans and every indication is that poaching has always been extensive.

Unoccupied or doubtfully occupied range. All suitable range is not occupied. Most notable is the north central part of the state and the Tunica hills of West Feliciana Parish. Any long-time management program should be centered about all or parts of the following parishes: Red River, Bienville, Jackson, Ouachita, Caldwell, Catahoula, LaSalle, Grant, Winn, Natchitoches. This entire region is characterized by a low rural farm population, a limited degree of cultivation, and a large continuous block of suitable forest land. It represents the approximate center of a large portion of the original state range. Of particular significance is the presence of the Catahoula and Kisatchie Divisions of the Kisatchie National Forest. Cooperative state and federal projects are essential for restoration in this area. The Tunica hills of West Feliciana Parish with a distinctive precipitous topography and an upland beech-magnolia forest is all in suitable range. Farming is limited, the human population low, and the entire parish affords a high degree of isolation.

Efforts should be made to establish managed areas in Vernon and Beauregard Parishes along the Sabine River and to correlate the work with that underway on the Devil's Pocket Refuge in Newton County, Texas.

The inauguration of spring hunting in 1945 in spite of the fact that the turkey population was obviously then at a critical low can only result in extermination and will undoubtedly nullify all other efforts. That restoration is possible has been demonstrated by other states dealing with last remnants. In Missouri Leopold and Dalke (1943) reported that the turkey population increased 20 per cent between 1935 and 1942. In Texas, according to Newman (1945) remnants of a flock were reported in the Spring of 1942, in Newton County. The 20,000 acre Devil's Pocket Refuge was established in this area, and 125 birds were recorded in 1943.

Restoration in Louisiana can be accomplished but extreme steps and an aggressive action program including an annual census, a better measure of protection, land acquisition and development, cooperative state and federal efforts on the national forests, and a trapping program to remove the birds from areas of encroaching agriculture to permanent refuge areas, are required.

SUMMARY

The original range of the wild turkey in Louisiana comprised 40 parishes and approximately 28,000 square miles and occurred in two large blocks constituting (1) all of the state east of the Mississippi River and north of Lake Pontchartrain, (2) that portion north of an irregular line drawn from the northwestern corner of West Feliciana to the southwestern corner of Calcasieu Parish.

The 1942 population was 158 flocks which occupied approximately 1,320 square miles or 5 per cent of the original range. The occupied range consists of small, widely separated and sharply limited units.

Seventy-eight per cent of the popula-

tion occurred in bottomland hardwood forests. Forty-two per cent of the population was found on or just adjacent to protected areas; these were the Singer-Ayer Refuge, the Morehouse Refuge, and the Urania Forest.

Significant turkey populations were associated with a low human farm population. But the average size of the farm and the average per cent of the parish in cultivation was identical for occupied parishes and for the state average.

The Singer-Ayer Refuge can not be considered as permanent range because of encroaching agriculture. It is suggested that the turkey population here be removed to areas where permanent management is possible.

The creation of management areas is suggested for four areas within the occupied range: (1) the juncture of Winn, Caldwell, and LaSalle Parishes; (2) the northern part of Livingston Parish; (3) the Pearl River bottomlands in St. Tammany and Washington Parishes; (4) the West Bay area of Allen Parish.

Restoration in unoccupied areas should be centered in the north central part of the state where the range is for the most part suitable and where federal forest land is available.

Restoration can be accomplished but extreme steps and an aggressive action program are required.

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DIFFERENTIAL ABILITY OF MALE AND FEMALE GAME BIRDS TO WITHSTAND STARVATION AND CLIMATIC EXTREMES

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Unequal sex ratios are known to exist within many species of wild birds. Ratios may vary by season, as well as by age, and figures may change greatly from one season to another. In an attempt to postulate the possible reason, or reasons, for this unbalanced condition between sexes, one may list several factors, most of which, either directly or indirectly, are the result of environmental influences. *Physiological*—differences in ability to withstand climatic severities and starvation. *Physical*—differences in degree of predation because of sexual dimorphisms, such as dissimilar functions during the mating and nesting seasons, difference in plumage colorations, and contrasts in alertness, speed, willingness to keep to cover, boldness, etc.; difference in hunting mortality at the hands of man, either through law, choice, or facility of capture; and fighting among males during the mating season. *Mechanical*—differences in mortality resulting from mowing, burning, highway kill, etc. *Pathological*—differences in the effects of diseases and parasites.

The ever-changing sex ratio within any specific population must be given special consideration by those responsible for the management of that species. This is particularly true in the case of those forms, such as the ring-necked pheasant, among which the annual harvested surplus is frequently composed of only one sex. Of perhaps even greater importance is the sex ratio of monogamous species within which it is necessary to have a balance of numbers or the surplus becomes wasted breeding stock.

One of the many enigmas encountered in the study of wild birds is the

reason, or necessity, for polygamy. Why one of two closely related species may be monogamous and the other polygamous has puzzled ornithologists for centuries. It is presumed that the natural inclination of all bird life originally was toward monogamy, but, because of many physiological and environmental changes affecting the birds, some species have from necessity become polygamous. If the assumptive explanation for polygamy (an unequal sex ratio favoring the female) is a truth, and the sex ratio at birth has been proven to favor the males in certain so-called polygamous species (ringnecked pheasant and others), then it is fair to assume that a higher mortality occurs in the male than in the female between birth and the first breeding season. It is also reasonable to believe that this difference may be manifested throughout the entire span of life.

This premise, however, will apply only in a natural state. An unequal sex ratio among adult birds may result from man's activities or the influences of his civilization, and not from basic physiological differences or pristine predation. There is little doubt that unbalanced sex ratios in some species can, and do, arise from this unnatural environment, and, consequently, the origin of all unequal ratios must be carefully established.

This paper reports the results of various experiments designed to show the physiological differential between the sexes—their comparative ability to withstand the hardships of a temperate climate, and, indirectly, to seek a possible explanation for polygamy in wild birds.

SEX RATIOS

Comparatively little has been recorded concerning the sex ratios of wild birds. The difficulty of determining accurately the proportion of sexes is immense, and most data have been secured from banding records and nestling counts. Although many species vary but little from the expected 1:1 ratio, others show marked deviation. A disproportion of the sexes amounting to as little as five or ten per cent could be highly significant in survival.

Mayr (1939) has compiled some information on sex ratios in wild birds and gives figures for a number of species. As an outstanding example of an unbalanced ratio, he cites the honeyeaters of the Australian region in which the ratio may favor the males as much as ten to one. He classifies sex ratios as follows: "The *primary* sex ratio relates to the proportion of the sexes at the time of fertilization, the *secondary* sex ratio at the time of birth, and the *tertiary* sex ratio during adult life." (Table 1 lists secondary ratios for five species, and tertiary ratios for sixteen species.)

McIlhenny (1940) in his studies at Avery Island, Louisiana, discovered that a wide difference may exist in nestling sex ratios even between species of the same family. The boat-tailed grackle *Cassidix mexicanus major*, a polygamous species, showed a preponderance of females in the ratio of 251:100 among 412 nestlings in 137 nests. The trapping records for the same species based on 5,333 individuals was also unbalanced with 201 females to 100 males. Inversely, the nestling ratio of the Gulf Coast red-winged blackbird

Agelaius phoeniceus littoralis, a monogamous species, proved to be 330 males to 100 females in 420 nestlings, and 543 males to 100 females in 6,480 banding records.

McIlhenny also reports pertinent tertiary ratios for nine species of wild ducks obtained from live trapping. Among all species except the mallard, the ratio averaged two to one in favor of the males, ranging from 335 to 167 males to each 100 females.

Stoddard (1932) established the sex ratio of the bobwhite quail in the south as being 114 males to 100 females. This figure is very close to that given by Emlen (1940) for California quail which was 112.2 males to 100 females. Both ratios were for adult birds.

Nice (1937) has pointed the way toward accurate and thorough sex ratio studies with her investigation of the song sparrow *Melospiza melodia*. During nesting seasons of six consecutive years (1930–35), she marked individually nearly every bird upon her study area, and figures for the six years show that at the beginning of the nesting season in April the sex ratio was approximately 105 males to 100 females, but by June, at the end of the season, the ratio had changed to 118 males to 100 females.

To determine the secondary sex ratio

TABLE 1.—SEX RATIOS IN WILD AND DOMESTIC BIRDS.

Authority	Species	No. of records	Ratio males:females
	Secondary ratios		
Byerley and Jull (1935)	Domestic fowl	96,008	97:100
Cole and Kirkpatrick (1915)	Pigeon	—	105:100
McIlhenny (1940)	Boat-tailed grackle	412	39.9:100
McIlhenny (1940)	Gulf Coast r.w. blackbird	420	330:100
Latham (See below)	Ringnecked pheasant	1,020	114.3:100
	Tertiary Ratios		
Mosby and Handley (1943)	Wild turkey	392	73:100
Leedy and Hicks (1945)	Ringnecked pheasant	64,337	39:100
Leopold (1933)	Ringnecked pheasant	33,655	35:100
Snyder (1935)	Sharp-tailed grouse	65	35:100
Stoddard (1932)	Bobwhite quail	19,423	*107–130:100
Stoddard (1932)	Bobwhite quail	10,707	*113–138:100
Stoddard (1932)	Bobwhite quail	845	130:100
Emlen (1940)	California quail	—	112.2:100
Lincoln (1932)	Mallard duck	21,958	127:100
McIlhenny (1940)	Ring-necked duck	6,116	335:100
McIlhenny (1940)	American pintail duck	23,674	198:100
McIlhenny (1940)	Blue-winged teal	8,027	180:100
McIlhenny (1940)	Lesser scaup	8,356	222:100
McIlhenny (1940)	Cowbird	4,281	282:100
McIlhenny (1940)	Gulf Coast r.w. blackbird	6,480	543:100
McIlhenny (1940)	Boat-tailed grackle	5,333	49.7:100
Hicks (1934)	European starling	2,522	211:100
Nice (1937)	Song sparrow (April)	450	105:100
	(June)	450	118:100
Wood (1938)	Goshawk	291	67:100

* Variations between reports from different observers.

of the ringnecked pheasant as a basis for the work discussed in this paper, the writer killed and sexed 1,020 day-old chicks reared upon the Pennsylvania State Game Farms. The resulting analysis revealed a ratio of 114.3 males to 100 females. Byerley and Jull (1935), from the examination of 96,008 chicks alive at hatching, found the secondary ratio for the domestic fowl to be 49.17 ± 0.11 per cent males. Cole and Kirkpatrick, working with the pigeon, set the ratio for that species at 105 males to 100 females.

METHODS AND PROCEDURE

This study involved the use of the laboratory equipment at the Pennsylvania Game Commission's Loyalsock Experiment Station known as the climoactometer (Gerstell 1938) with which the operator may simulate various meteorological conditions in a chamber six by eleven feet. Groups of birds of various ages were placed in this chamber, and, for the most part, were subjected to conditions typical of those which wild birds would be likely to encounter. Adverse meteorological factors (high or low temperatures, cold rains, high winds and humidity), either singly or in combination, were coupled with complete fasting to effect the ultimate death of all experimental birds. Immature birds, on which the external sex characteristics were not developed, were opened and sexed following death. The time of death for each bird was noted accurately, which necessitated a continuous check in all experiments except those lasting several days.

Thirty-three separate experiments, in which 1,332 game birds were sacrificed, constitute the basis for the figures and results given in this paper. In order to make the most practical use of the birds involved, experiments were performed which not only gave the sex differential information desired, but also other important physiological data.

POLYGAMOUS SPECIES

Ringnecked pheasant (*Phasianus colchicus torquatus*). Of the 27 experiments with pheasants, 8 groups were used in rain tests. Three of these groups, ranging from 3 to 6 days old, were subjected to a "summer shower". In the first test the birds were exposed to a heavy ten-minute rain with the temperature at 50°F. (Exp. 9; Fig. 1). Following the rain, the temperature was allowed to rise to 70°F. This test was repeated with another lot of birds with the rain at 60° and a temperature rise to 80° (Exp. 10; Fig. 1). Similarly, a third test was conducted with the rain at 70° and the rise to 90° (Exp. 11; Fig. 1). All birds were allowed to die in these tests even though they may have recovered temporarily from the wetting and chilling.

In another experiment, a number of chicks were dipped in cold water until thoroughly wet and placed in a room at 65° (Exp. 6; Fig. 2). Day-old chicks were placed in the chamber and remained in a constant cold rain until all had succumbed (Exp. 4; Fig. 1). The birds in the remaining three rain experiments were subjected to rains at 50°F. (Exps. 3, 6; Fig. 1 and Exp. 4; Fig. 2).

Four heat tests included four age groups. In these the temperature and humidity were maintained constantly at 108° F. and 65 per cent respectively (Exp. 2, 8, 9; Fig. 2 and Exp. 1; Fig. 1).

Temperature variations of from 0° to

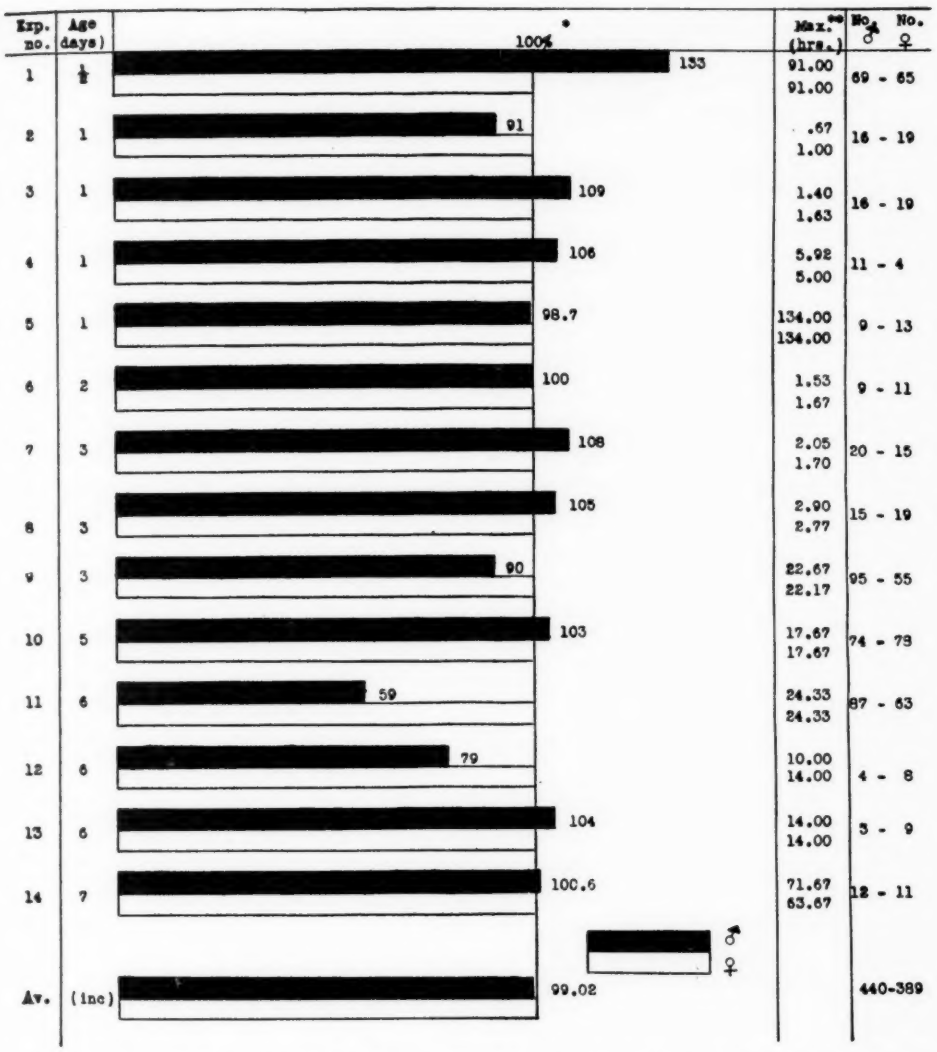

FIG. 1.—Differential response of male and female ringnecked pheasants aged one to seven days to fasting and exposure (polygamous species).

* The average survival time for females in each experiment is designated as 100% so that the like figure for males can be shown as a comparative percentage.

** Represents the survival time in hours of the longest-lived individual of either sex.

96° were used in the fourteen fasting and exposure experiments. In one of these, six mature birds were subjected to a temperature of 0°F. and a constant wind of 5.8 m.p.h. (Exp. 12; Fig. 2). None of these birds had either food or water during the test. Twenty-five mature pheasants were held in an outside pen with no food (snow was available during most of the experimental period)

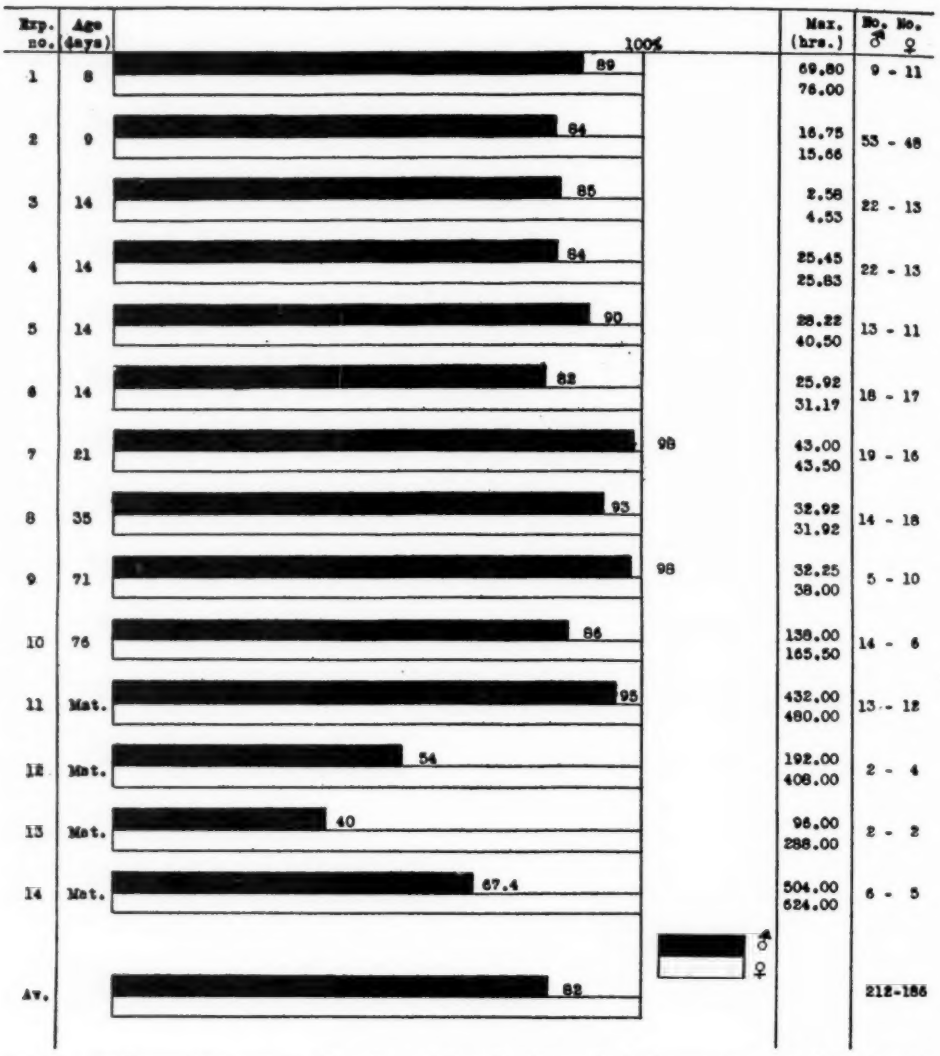

FIG. 2.—Differential response of male and female ringnecked pheasants aged eight days to maturity to fasting and exposure (polygamous species).

and allowed to remain until all had died. The birds were exposed to the extremely cold and stormy part of the 1939–40 winter (Feb. 1–21) with temperatures varying from a minimum of 2°F. to a maximum of 57°F. (Exp. 11; Fig. 2).

Four mature pheasants, two cocks and two hens, were fasted at 95°F. (Exp. 13; Fig. 2). The remainder of the fasting and exposure studies involved immature birds. One group seventy-six days old was fasted at 75°F. (Exp. 10; Fig. 2). Another lot twenty-one days old was fasted at 60°F. (Exp. 7; Fig. 2). The age of the birds utilized in the

final ten experiments ranged from two weeks to one day, and all were fasted at temperatures from 50°F. to 96°F.

Ruffed grouse (*Bonasa umbellus*). The experimental data on the ruffed grouse are limited (Fig. 3). Only six pen-reared grouse were utilized in a typical fasting experiment. Two birds were exposed at 0°F. with a constant 5.8 m.p.h. wind; two at 0°F. with no air movement; and two at 37°F. to 50°F. with no air movement.

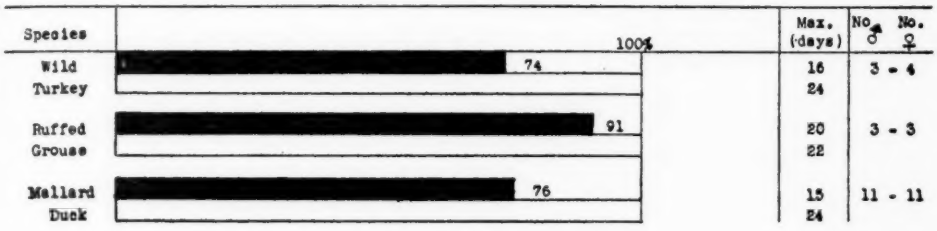

FIG. 3.—Differential response of male and female wild turkeys, ruffed grouse, and Mallard ducks to fasting and exposure (polygamous species).

Wild turkey (*Meleagris gallopavo*). An identical test as that described above for the ruffed grouse was completed for the wild turkey, with an additional two birds fasted in an unsheltered outdoor pen in late winter.

Mallard duck (*Anas platyrhynchos*). Twenty-two mallards were also subjected to the three temperature-wind combinations described for the ruffed grouse.

MONOGAMOUS SPECIES

Bobwhite quail (*Colinus virginianus*). Ten pairs of quail were caged individually and held in the climoactometer at 0°F., five pairs in a 5.8 m.p.h. wind and five pairs without air movement. Five other pairs were placed in a cage as a group and subjected to 0°F. with no wind. Four pairs of control birds were fasted at 36°F. to 44°F. (Fig. 3). Three other quail studies of a different nature, but demonstrating the physiological differences between the sexes, will be described later. One of these was an accidental comparison of mortality during extreme heat, and the other two are comparisons of weight loss during temporary fasting.

Hungarian partridge (*Perdix perdix*). Six "Huns" were tested in the usual manner—that is, one pair at 0°F. with a 5.8 m.p.h. wind; one pair at 0°F. with no air movement; and one pair as control birds at 34°F. to 39°F. (Fig. 3).

DISCUSSION

A number of physiologists have found significant sexual differences in metabolic rates and body temperatures in several avian and mammalian species. Benedict (1938) has stated that there is a difference in the metabolism of males and females in humans, ruminants, horses, fowl, and other animals. He writes: "Whether the difference noted between sexes (humans), which may be as great as fifteen to twenty per cent, is ascribable to a difference in the endocrine system, or whether it is determined by the larger fat content in

the woman's body, is difficult to determine, but it is a fact that there is a marked difference between the two sexes."

Riddle, Christman, and Benedict (1930) have discovered from metabolism studies the existence of a sex differential in birds. They state: "From 589 measurements made at 20° and 30°C. on males and females of 16 standardized races of ring doves, it is definitely established that the metabolism of the male suffers a greater decrease with increase of external temperature than does that of the female.

"This differential response of the normal metabolism of the sexes to temperature is of much consequence not only in metabolism studies, but in growth, vitamin and nutritional research, and in experimental biology generally."

Riddle, Smith, and Benedict (1932) observed a higher standard metabolism in the male mourning dove; and Baldwin and Kendeigh (1932) found the body temperature of the female house wren averaged 0.6°F. higher than that of the male.

Records of the comparative survival between sexes in wild birds are meagre. Stoddard (1932) writes: "Data obtained from the shooting and retrapping of banded bobwhites throw some light on sex ratio and reveal the strong probability that the hens have a decidedly shorter 'life expectation' when living under natural conditions than do the cocks." Both from retrapping and shooting, the banding records show a disproportionate mortality in the female. In like manner, the ratio during spring trapping showed higher percentages of cocks than the "shooting" figures of the previous fall. Kendeigh (1945) in fasting experiments with the English sparrow (*Passer domesticus*) found that the survival time for the females was shorter than the average for the species.

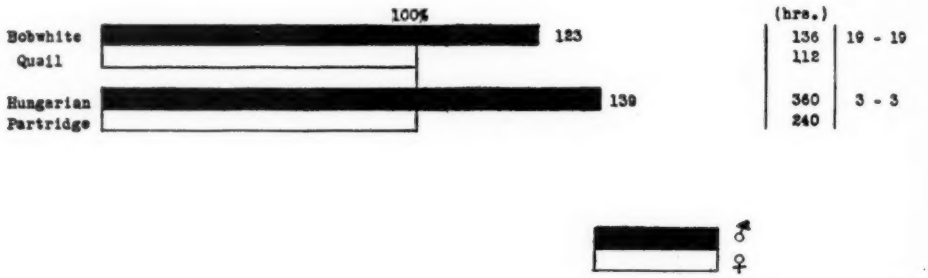

FIG. 4.—Differential response of male and female Bobwhite quail and Hungarian partridges to fasting and exposure (monogamous species).

For wild ducks, McIlhenny (1940) has records showing the sex ratio for birds still alive four years after banding in three species. For pintails (*Dafila acuta*), the ratio of live birds after four years was 250 males to 100 females. The banding ratio for this species was 196 to 100. The ratio for the lesser scaup (*Nyroca affinis*) after four years was 300 to 100, with a banding ratio of 222 males to 100 females, and for ring-necked ducks (*Nyroca collaris*) was 490

males to 100 females, with a banding ratio of 335 to 100. These records show clearly the greater mortality among females in adult ducks of at least three species. The explanation of this unequal loss may very well lie in the difference in reproductive functions of the two sexes. During egg-laying and incubation, the female is particularly susceptible to predation, while the male is comparatively safe because of his gregarious habit during that time.

The work at the Loyalsock Experiment Station confirms the existence of a physiological difference between the sexes. Except for studies involving very young chicks from twelve hours to a few days old, female ringnecked pheasants exhibited a superior ability to withstand climatic extremes and starvation. During the first week the male chicks held a slight edge by showing superior stamina in eight of the fourteen tests (Fig. 1). It was evident, however, that even after five days the balance was swinging toward the side of the females, and the final analysis of the figures for this group showed the males one per cent less resistant than the females. This change from male to female superiority within the first few days after hatching is believed by the writer to correspond closely with the development of homeothermy within the chick. In the domestic fowl, true homeothermy is believed to be acquired about the fourth or fifth day after hatching (Romanoff 1929), and this perhaps may be equally true in the closely related pheasant chick.

The evident superiority of the males at a very early age led the writer to investigate the differential mortality during hatching—that is, of those that hatched but died shortly or were killed as cripples; of those that pipped but were unable to emerge; and of those that were dead in the shell. Table 2 presents these figures for 999 nonsurviving chicks. The greater loss of female chicks during this phase of development may likely be the explanation for the preponderance of males in the secondary sex ratio—114:100.

TABLE 2.—SEXES OF CRIPPLED, DEAD, AND UNHATCHED RINGNECK CHICKS.

	Females	Males
427 crippled and dead chicks	211	216
241 pipped but not hatched	130	111
331 unpipped (dead in shell)	175	156
999 total	516	483

In the experiments with ringnecks aged eight days to maturity, the hens showed superiority in every instance, usually by a pronounced margin. The males in this category averaged only 82 per cent as resistant to hardships as the females (Fig. 2). In the adult stage, the difference in survival times was quite pronounced (males 64 per cent—females 100 per cent), even though the male averages about one-third heavier than the female.

In all of the 28 separate pheasant experiments, 82 of the last 115 birds to die were females, and 33 were males.

Another investigation concerning the differential mortality among artificially-reared pheasants was made with the birds that died during the first seven weeks in the brooders and holding fields. Of the 602 birds lost during this time, 54.8 per cent were males. As would be expected, the greatest mortality occurred during the first three weeks, so that a preponderance of very young

pheasants make up the 602 total, and very few five-, six-, and seven-week old birds are included.

The average survival time for the males of the other three polygamous species was, as in the case of the ringneck, less than that for the females (Fig. 3). The eleven drake mallards lived an average of 9.2 days as compared to 12.1 days for the eleven hens. Although only three ruffed grouse of each sex were used in the fasting tests, the final average favored the hens 22 days to 20 days. Three tom turkeys lived only an average of 11.3 days, but the four hens lasted 15.2 days. The numbers of these three polygamous species used in the tests were too few to permit positive conclusions, but the findings are believed to be indicative.

The fasting experiments involving bobwhite quail gave a composite average of 81.3 hours of survival for the cocks and 66.0 hours for the hens. The maximum survival for males was 136 hours as compared to 112 hours for females.

A second test was accidental. Twenty pairs of mature quail were inadvertently held in the closed trunk of an automobile for approximately one hour on a hot spring day. The temperature probably reached a point somewhere between 110°F. and 120°F. beneath the hot metal. When the birds were released, only ten remained alive, and *nine of these were males.*

In preparation for egg production investigations in 1941 at the Loyalsock Experiment Station, 20 pairs of quail were fasted until all had lost approximately 30 per cent of their body weight. During the first week of complete fast, the males lost 28.7 per cent of their initial weight, and the females suffered a 31.3 per cent loss. At the beginning, the cocks averaged 187.3 grams and the hens 185.7 grams.

During January, February, and March of 1946, nine pens of quail (five pairs in each) were held on nine different rations in an effort to determine the relationship of diet to reproduction. To simulate the temporary reduction of the natural food supply during heavy snows, the daily intake was reduced by approximately fifty per cent for several days at a time. Although the fasting periods were of short duration, the loss in body weight between the sexes was significantly higher in the females in all but one of the pens, and, in this instance, two of the five females died during the fasting period so that their weight losses could not be included in the analysis. The original weights of both sexes were nearly the same, although in six of the eight pens the males averaged slightly heavier.

Experiments with the only other monogamous species studied, the Hungarian partridge, indicated that the males, as in the bobwhite quail, possess superior stamina. The males lived an average of 9.7 days, the females 7.0 days.

SUMMARY

A series of experiments with six different species of game birds, which included 1,332 individuals, pointed toward a significant difference between the sexes in their ability to withstand fasting and climatic extremes. Among polygamous species, the females proved the stronger; and among monogamous species, the reverse was the case.

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SIMULATED BURROW SYSTEMS FOR STUDIES WITH RODENT PESTS

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Proper control of rodent pests is an important factor in the health and economy of a nation, and the control of rodents which burrow in the ground is a problem which demands the use of special techniques. Traps and poisoned baits, although often effective in controlling these animals, leave much to be desired, and fumigation of the burrow systems with toxic gases, vapors, smokes and dust is frequently used.

In the course of research on a method of fumigation by means of a rodenticide cartridge, it was found necessary to simulate the natural burrow systems of the various animals. Several burrows were constructed and tested, and the two systems described in this report were found to be highly satisfactory.

The first burrow system, used with rats and mice, is shown in Fig. 1. It was made by wiring together straight, curved, or T-shaped tubular sections of quarter-inch mesh wire screen. The entire system was covered with 3 to 4 inches of tightly packed moist soil. The use of quarter-inch screen made it possible to simulate natural burrows very closely because it allowed for the construction of discrete tunnels entirely surrounded with earth. Such tunnels can be made practically any size or shape by joining the proper tubular sections of screen.

The sections used in this study were 12 inches long and two inches in diameter. The total length of the burrow system built with them was 56 feet. The longest continuous burrow was 28 feet in length. The system had four entrances and a chamber in which the animals were kept during experiments. The entrances were the following distances from the chamber: No. 1, 12 feet; No. 2, 12 feet; No. 3, 16 feet; No. 4 15 feet.

The chamber was cylindrical in shape, tapering 4 inches from one end, with a maximum diameter of 10 inches. A rubber gasket was taped onto the large end of the chamber, and during experiments, a glass window was pressed against the gasket to provide a tight seal and a clear view of the animals exposed to the gases and smokes. The animals were prevented from going into the burrow proper by a screen wired across the small end of the chamber.

The burrow system lay flat on the ground with the exception of 4 loops which rose approximately 10 inches above ground level at their highest point. All loops were built on mounds of soil rather than being dug below the level of the ground, to reduce the possibility of rain water accumulating in the burrow. This type of burrow is characteristic of those dug by rats, ground squirrels and pocket gophers.

To provide means of sampling for toxic materials in the burrow system, glass tubes, held in position by rings of adhesive tape, were inserted through the earth into the burrow at the desired positions.

The toxicities of the various fumi-

gants tested were determined by placing rats or mice in the chamber, the behavior of these animals during the exposure being observed through the glass window. If it is desired to allow animals freedom of movement throughout the entire system, the loops and curves should be eliminated and the diameter of the burrow adjusted to the size of the animal being used. If the dips and curves are not removed, it may be difficult to retrieve the animals at the conclusion of the experiment. When it is desirable to study the action of animals in the burrow during experiments, windows can be placed in the system by inserting short cylinders of cellulose acetate between the screen tubes.

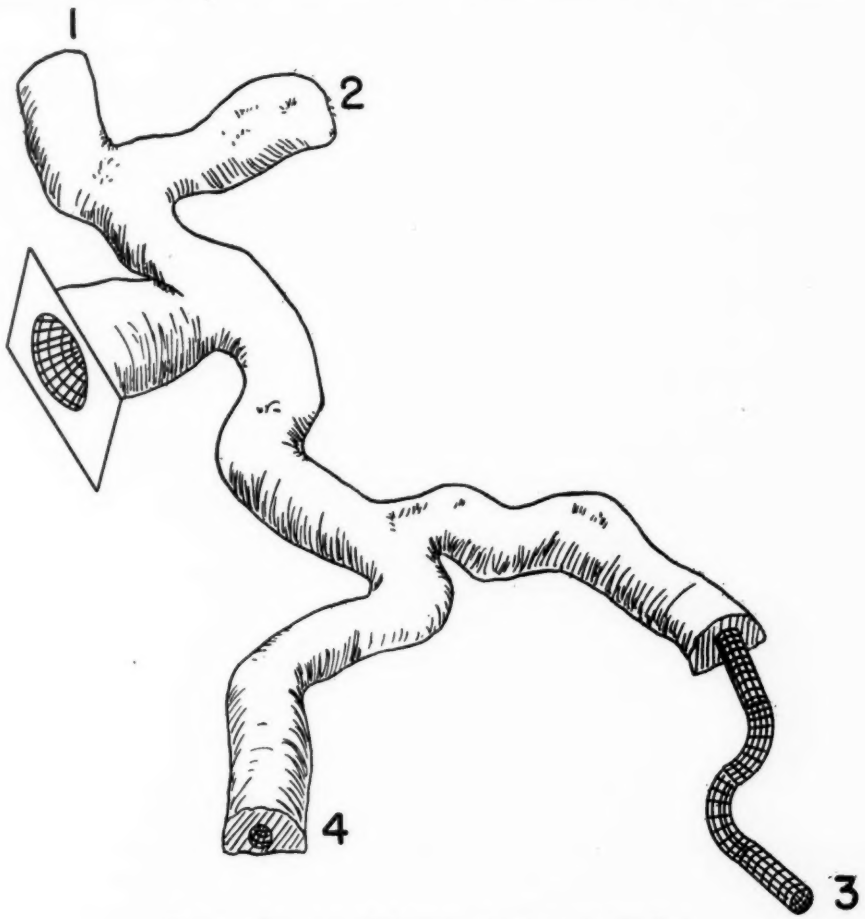

FIG. 1.—Screen mesh burrow, showing construction.

The second burrow system used by this laboratory resembled those dug by prairie dogs and woodchucks. It consisted of 3 straight underground shafts forming a continuous system (Fig. 2). The holes were made with a fence post

auger with a 10 foot extension. In constructing this burrow, use was made of the vertical bank of a small stream. One hole (A), perpendicular to the face of the bank, was 11 feet long and descended from the horizontal at an angle of about 15 degrees. A vertical shaft (B) connected with the far end of this burrow, 5 feet below the surface of the ground. A 10 foot tunnel (C), descending from the horizontal at an angle of about 20 degrees, joined approximately at right angles to the other 2 at their point of juncture.

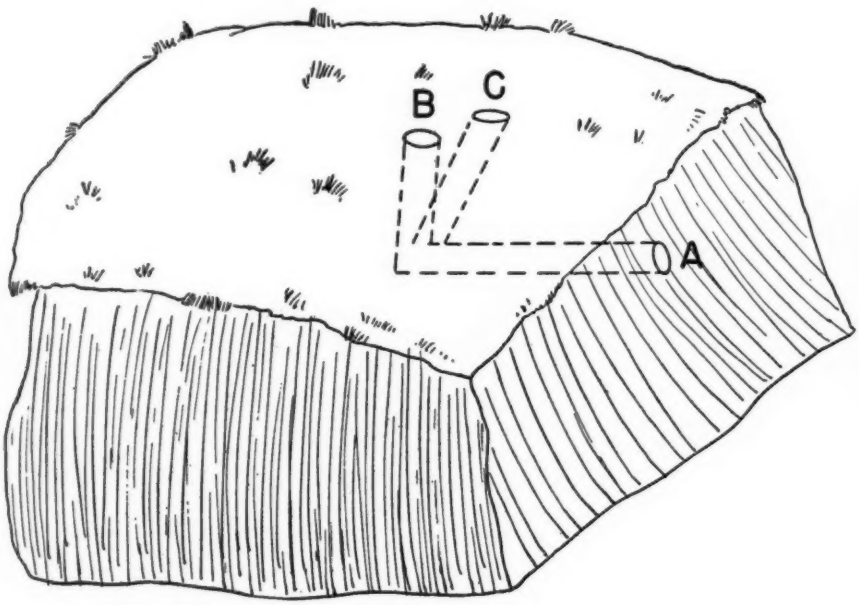

FIG. 2.—Simulated earth rodent burrow.

All of these holes were roughly 8 inches in diameter; they could have been made smaller or larger by the use of the proper size auger. The system had a capacity of approximately 250 liters. Glass windows, placed over each of the entrances and sealed with moist earth, permitted observation of the behavior of the animals during the experiments. The animals were either caged or allowed to wander freely through the burrow. Shaft B served as a skylight for the system. Hence, all of shaft A was visible through the A window. Similarly, the entire C burrow could be viewed through the C window.

This second burrow system proved to be very useful for studying the behavior of small animals exposed to toxic gases and smokes. For example, white rats often could be seen to leave relatively uncontaminated regions in the burrow to go into pockets of irritating smoke and gas. The burrow system was also used to compare the persistence and diffusibility of gases and smokes in an earth burrow.

In addition to fumigation tests, both the screen burrow and the bank burrow can be used to study the feeding, nest-

ing and breeding habits of wild animals. Since rodent pests are able to dig out of the bank burrow, the latter can be used only for short-time experiments. These might include a study of the burrowing habits of the animal, or a study of the effects of light, sound, odor and heat on animals.

MUSKRAT PELTS: SECTIONAL AND SEASONAL EFFECTS ON GRADES

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The large areas of marshland necessary as resting and feeding places for migratory waterfowl in transit between their summer and winter homes provide ideal natural habitat for the muskrat (*Ondatra zibethica*). When they occur at desirable densities muskrats perform valuable work in keeping dense marsh vegetation opened up thus creating a better habitat for waterfowl. The Federal Government has provided and is operating 291 National Wildlife Refuges in all parts of the United States under the supervision of the Fish and Wildlife Service. Muskrats on many of these areas are considered to be an annual crop and their numbers are so regulated as to create optimum conditions for migratory birds. Trapping operations conform to the regulations of the various States. Where out-of-season trapping is required to protect the dikes, special permits are obtained from the States. In most instances muskrats are trapped on shares, an equitable division is made of the skins, and the Government's share is sold through two fur auction houses in central markets. The net receipts are deposited in the U. S. Treasury after 25 per cent have been remitted to the counties in which the refuges are located.

With the cooperation of the Refuge Division of the Fish and Wildlife Service and the managers on selected National Wildlife Refuges, arrangements were made during several years to segregate the muskrat skins by semi-monthly periods for the entire trapping season. Auction companies assigned an expert grader of muskrat skins to grade and record by semi-monthly period the number of skins in each grade. The same grader at each auction company handled all the skins for the period of three years covered by the present paper, an arrangement which assured uniformity and made information from the different years comparable. There were 204 grades according to the size, quality of fur and skins, damages, condition of pelt, and kits. An analysis was made of the information obtained each year, and reported through a mimeographed release restricted to official personnel to assist in their operations. The present article is a summarization of the three years' study. For this particular

[1] Now in U. S. Department of Agriculture, Washington, D. C., by transfer of fur farming activities of the Fish and Wildlife Service to that Department.

study information from the refuges in certain sections was combined. A total of seven typical areas or sections are reviewed here.

Muskrat skins from certain areas have definite qualities as well as special uses and are usually classified for sale with these regional designations. Though the grade specifications of muskrat skins from the various regions are in general the same, too close a comparison should not be made in the following tables.

The grades "spring," "winter," and "fall" are fur-trade terms that reflect the degree of primeness. Fur dealers, however, have different ideas regarding the three grades. In general, the skins so classified were taken during the seasons named, but the percentage distribution to each class at any particular time of the year varied from year to year, depending upon climatic conditions. The amount of dark pigment (indicating pigment in the roots of the fur not yet fully grown out) on the flesh side is the

TABLE 1.—MEASUREMENTS[a] OF RANDOM SAMPLES OF TEN OR MORE MUSKRAT SKINS OF EACH SIZE TAKEN DURING 1945–46 TRAPPING SEASON FROM SEVERAL NATIONAL WILDLIFE REFUGES AS GRADED BY AUCTION COMPANIES.

Size	Average width	Average length	Average width	Average length	Average width	Average length
	Valentine Refuge (Neb.)		Lower Souris Refuge (N. D.)		Camas Refuge (Idaho)	
	inches	*inches*	*inches*	*inches*	*inches*	*inches*
XXX L	6.7	13.8	6.8	14.2	6.7	13.6
XX L	6.7	13.3	6.7	13.2	6.7	13.1
X L	6.6	13.0	6.6	12.7	6.7	12.6
L	6.6	11.7	6.5	11.5	6.6	11.8
L–M	6.5	11.0	6.6	11.1	6.5	10.8
M	6.5	10.5	6.5	10.7	6.5	10.2
S	6.3	9.9	6.5	10.0	6.4	9.7
	Tule Lake Refuge (Calif.)		Mud Lake Refuge (Minn.)		Horicon Refuge (Wis.)	
XXX L	6.4	14.3	7.5	13.1	7.0	13.4
XX L	6.4	13.7	7.1	12.8	7.0	12.3
X L	6.5	12.4	7.1	12.0	6.5	11.5
L	6.2	12.1	6.9	11.6	6.4	11.2
L–M	—	—	—	—	6.3	10.5
M	6.2	10.4	6.9	10.8	6.2	10.3
S	6.1	9.5	6.9	10.2	6.0	10.1
	Montezuma Refuge (N. Y.)		Squaw Creek Refuge (Mo.)		Sabine Refuge (La.)	
XXX L	7.4	13.7	7.1	13.2	7.3	10.5
XX L	6.9	12.9	6.8	12.5	7.3	10.0
X L	6.8	12.0	6.7	12.2	7.2	9.7
L	6.9	11.2	6.5	11.7	7.2	9.6
L–M	—	—	—	—	—	—
M	6.5	9.9	6.6	10.6	6.8	9.1
S	6.4	9.7	6.3	10.4	6.7	8.6

[a] Measurements made from eyeholes to cross line connecting the extreme rear points of each side of the pelt and the distance between these two points.

most characteristic feature. "Spring" skins usually are devoid of the blue color on the back of the skin but may have a narrow streak of light blue on each side of the middle as viewed in the back. Representative "winter" skins are usually clear in the center of the back but may have a narrow to medium streak of light blue color down the center of the back and possibly somewhat wider blue streaks on the sides than do "spring" skins. "Fall" skins may have irregular spots of darker blue pigment showing or a greater degree of pigment than found on winter skins (Journ. Wildl. Man., **10** (1) pp. 38–42). Naturally there are intergrades of these main classifications difficult to classify, and the group into which they are finally placed depends upon the judgment of the grader. Some "winter" grade skins may be trapped in late spring and "spring" grade during the winter.

The same flexibility exists for size grading. For example, a skin may be classified as XXXL by one grader and by another as XXL. There are no fixed standards in the fur trade, though in general fur tradesmen operate similarly. In grading for size, a quick estimate must be made of the relative number of square inches of skin when uniformly and naturally stretched. Length of skin alone cannot be considered for some skins are stretched wider than others, and some skins are over-stretched. A proper understanding of these matters can best be obtained by seeing the great variation in muskrat skins received at an auction company. Tables 1 and 2 show the variability of sizes of muskrat skins from various sections as well as variation in size grades by different graders. Uniform skins stretched to the desired size and shape present an attractive appearance and are more readily saleable at a higher figure than poorly handled ones.

TABLE 2.—AVERAGE AREA DETERMINED BY PLANIMETER OF 20 MUSKRAT SKINS SELECTED AT RANDOM FROM EACH SIZE AS GRADED BY AUCTION COMPANIES FROM THREE NATIONAL WILDLIFE REFUGES, SEASON 1943–44.

Size	Tule Lake Refuge	Mud Lake Refuge	Delta Refuge
	sq. inches	sq. inches	sq. inches
XXX Large	105.48	81.25	73.50
XX Large	84.18	66.51	66.60
X Large	80.97	62.90	59.25
Large	75.44	58.03	54.18
Lge.-Med.	65.34	56.84	50.13
Medium	60.29	53.27	46.25
Small	55.12	—	45.00

The "slightly damaged" group comprises skins with one small hole or cut in the back. These slight holes tend to enlarge in the process of dressing. The increased number and size of holes cause the skins to be placed in other assortments.

The term "kits" refers naturally to the skins from the younger animals, but in grading muskrat furs emphasis is placed upon the lack of guard hairs. The under-fur and the pelt itself have less substance than in older skins.

The number of skins taken over the three year period (a few refuges only two years or one year) 1943–46 within each grade of each of the sections was tabulated. These data were then analyzed on the basis of various qualities and conditions of the pelts and on trapping periods, such findings being presented in percentage relationship to make comparisons more readily.

TABLE 3.—PERCENTAGE DISTRIBUTION BY QUALITY OF FUR AND PELT IN RELATION TO PRIMENESS OF MUSKRAT SKINS TAKEN FROM NATIONAL WILDLIFE REFUGES IN VARIOUS SECTIONS OF THE UNITED STATES. TOTAL OF THREE YEARS 1943–46.*

Refuges	Section	Primeness	Quality			Number
			Heavy fur	Light fur	Light pelt	
Mud Lake, Minn.	A	Spring	47.6	46.8	5.6	504
Seney, Mich.		Winter	36.7	58.1	5.2	9,571
Necedah, Wis.		Fall	40.3	57.2	2.5	11,316
Horicon, Wis.						
		Av.	38.8	57.4	3.8	21,391
Montezuma, N. Y.	B	Spring	57.5	40.5	2.0	2,029
		Winter	63.9	34.6	1.5	5,182
		Fall	73.7	26.1	0.2	1,255
		Av.	63.9	34.7	1.4	8,466
Squaw Creek, Mo.	C	Spring	57.9	42.1	—	57
Big Lake, Ark.		Winter	37.1	61.3	1.6	1,542
		Fall	47.3	52.5	0.2	1,565
		Av.	42.5	56.6	0.9	3,164
Malheur, Ore.	E	Spring	79.7	7.5	12.8	9,625
Tule Lake, Calif.		Winter	84.0	10.0	6.0	11,826
		Fall	65.2	25.3	9.5	9,379
		Av.	76.9	13.9	9.2	30,830
Camas, Idaho	F	Spring	81.3	4.4	14.3	2,841
Bear River, Utah		Winter	93.1	2.0	4.9	1,633
		Fall	94.3	4.2	1.5	336
		Av.	86.2	3.6	10.2	4,810
L. Souris, N. D.	G	Spring	77.1	13.1	9.8	5,737
S. Lake, S. D.		Winter	83.6	11.9	4.5	8,816
Lacreek, S. D.		Fall	65.7	27.8	6.5	2,125
Valentine, Neb.						
		Av.	79.0	14.4	6.6	16,678
			I	II		
Delta, La.	D	Spring	56.5	43.5	—	3,407
Sabine, La.		Winter	48.2	51.8	—	32,802
		Blue	46.6	53.4	—	17,864
		Av.	48.2	51.8	—	54,073

* See footnote table 5 for exceptions.

The quality of the fur varies with different sections. A heavy furred muskrat from the Louisiana sections would be even thinner furred than some light furred skin from the New York or Wisconsin sections which produce the "sealing" skins. By "sealing" skins is meant those having a heavy enough under-fur when the skin is plucked and sheared to simulate the density of the Alaska seal skin. In general (Table 3) a higher percentage of the "spring" skins are heavier furred than the "winter" and these in turn than the "fall." The per-

centage of "light pelt" skins is higher in the "spring" classification. This particular type of skin is heavy furred but the "leather" is lighter in weight than that of the ordinary skin. As expected, the "fall" skins have the higher percentage of light-furred skins.

ern areas the percentage of "fall" skins is quite high until the last two weeks of December and the "spring" skins do not exceed 50% until about February 1. The Louisiana section has only a slight fluctuation throughout the trapping season. The variation of these prime-

TABLE 4.—PERCENTAGE DISTRIBUTION BY SIZE OF MUSKRAT SKINS TAKEN FROM NATIONAL WILDLIFE REFUGES IN VARIOUS SECTIONS OF THE UNITED STATES. TOTALS OF THREE YEARS 1943–46.*

Sizes of skins	Refuges						
	A	B	C	D	E	F	G
XXX Large	*16.2*	*41.2*	*19.0*	*7.4*	*6.2*	*1.5*	*3.2*
XX Large	*21.5*	*28.9*	*23.8*	*20.0*	*9.2*	*4.0*	*6.8*
X Large	*24.5*	*16.4*	*25.2*	*25.8*	*17.6*	*13.0*	*16.6*
Large	*24.6*	*10.9*	*21.7*	*27.1*	*39.8*	*39.4*	*41.4*
Lge.-Med.	*2.6*	*0.1*	—	—	*10.0*	*13.5*	*12.3*
Medium	*6.6*	*1.8*	*6.5*	*11.8*	*9.3*	*14.3*	*11.3*
Small	*3.6*	*0.6*	*3.5*	*6.2*	*7.8*	*14.3*	*8.4*
X Small	*0.4*	*0.1*	*0.3*	*1.7*	*0.1*	—	—
Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Number of skins	22,860	9,452	3,246	58,658	33,670	5,893	18,842

* See footnotes to Table 5, for exceptions. Skins originated from refuges listed in Table 3.

The percentage distribution of the skins from the various sections according to size is shown in Table 4. A comparison of data from the different sections should not be too critical since it is the opinion of many fur men that similar size-grades of skins from different areas are not necessarily comparable in actual size of skins. In other words, each area has a size gradation peculiar to that area. Other fur men do not concede this point except in extreme cases, such as Louisiana. Also, graders of skins in the same area do not necessarily agree as to just what comprises a "large" skin.

The seasonal effect on percentage distribution of the "spring," "winter," and "fall" classifications for the 3-year period is shown in Table 5. In the northness grades from one season to the next is shown in Figure 1.

Damage to muskrat skins increases sharply after March 1 and in some cases amounts to as much as 50% by the end of the month (Table 6). This is the initiation of the spring breeding season. The percentage of "kits and mice" is somewhat larger in the fall except in Louisiana where it remains quite constant throughout the trapping period.

There is no definite information on the relative monetary value of different grades of muskrat skins. This could be obtained readily for the immediate time of any sale by lotting sufficient quantities of a specific grade and offering numerous such lots of skins at public auction. Such a study is contemplated by the Fish and Wildlife Service. The

TABLE 5.—PERCENTAGE DISTRIBUTION BY "DEGREE OF PRIMENESS" IN RELATION TO SEMI-MONTHLY TRAPPING PERIODS OF MUSKRAT SKINS TAKEN FROM NATIONAL WILDLIFE REFUGES IN VARIOUS SECTIONS OF THE UNITED STATES. TOTALS OF THREE YEARS 1943–46.

Trapping periods	Skins classified	Degree of primeness			Skins classified	Degree of primeness		
		Spring	Winter	Fall		Spring	Winter	Fall
	Refuges: Mud Lake (Minn.), Seney (Mich.) Necedah[a] (Wis.), Horicon (Wis.)				Refuges: Malheur (Ore.), Tule Lake[b] (Calif.)			
Nov. 1–30	13,515	0.1	39.1	60.8	4,741	—	—	100.0
Dec. 1–15	6,056	2.8	53.5	43.7	4,690	0.8	20.4	78.8
16–31	2,530	8.4	55.8	35.8	4,374	0.8	79.4	19.8
Jan. 1–15	759	25.3	63.8	10.9	3,139	26.8	68.7	4.5
16–31	—	—	—	—	3,715	62.4	36.9	0.7
Feb. 1–15	—	—	—	—	5,798	65.6	34.3	0.1
16–29	—	—	—	—	3,682	89.1	10.8	0.1
Mar. 1–15	—	—	—	—	621	87.0	13.0	—
	Refuge: Montezuma (N. Y.)				Refuges: Camas[c] (Idaho,) Bear River[d] (Utah)			
Nov. 1–30	—	—	—	—	375	6.9	64.7	38.4
Dec. 1–15	211	—	46.9	53.1	648	4.8	78.1	17.1
16–31	—	—	—	—	535	9.2	75.9	15.0
Jan. 1–15	1,771	10.6	57.4	32.0	334	8.7	81.4	9.9
16–31	2,240	9.7	69.2	21.1	176	21.6	70.4	8.0
Feb. 1–15	1,629	14.2	77.0	8.8	78	10.2	79.6	10.2
16–29	1,377	38.3	60.6	1.1	118	99.2	0.8	—
Mar. 1–15	1,495	62.4	37.6	—	2,244	95.2	4.8	—
16–31	729	63.9	36.1	—	964	99.3	0.7	—
Apr. 1–15	—	—	—	—	309	100.0	—	—
	Refuges: Squaw Creek (Mo.), Big Lake (Ark.)				Refuges: Lower Souris (N. D.), Sand Lake (S. D.), Lacreek (S. D.), Valentine,[e] (Neb.)			
Nov. 1–30	17	—	76.5	23.5	979	0.8	15.1	84.1
Dec. 1–15	1,351	0.2	41.2	58.6	1,979	0.8	71.3	27.9
16–31	1,531	1.0	52.6	46.4	1,661	0.2	82.4	17.4
Jan. 1–15	347	12.1	61.1	26.8	2,555	3.4	82.1	14.5
16–31	—	—	—	—	2,505	18.2	76.3	5.5
Feb. 1–15	—	—	—	—	1,416	26.3	72.5	1.2
16–29	—	—	—	—	1,657	54.7	45.3	—
Mar. 1–15	—	—	—	—	607	71.2	28.8	—
16–31	—	—	—	—	2,520	90.3	9.7	—
Apr. 1–15	—	—	—	—	2,502	97.8	1.7	0.5
16–30	—	—	—	—	461	97.2	2.8	—
	Refuges: Delta (La.), Sabine[f] (La.)							
Dec. 1–15	11,993	1.1	58.0	40.9				
16–31	13,132	1.3	59.9	38.8				
Jan. 1–15	8,001	4.0	65.8	30.2				
16–31	14,049	8.0	67.5	24.5				
Feb. 1–15	11,190	17.5	53.2	29.3				
16–29	294	—	73.8	26.2				

[a] Necedah—year 1944–45 only.
[b] First 2 months of Tule Lake 1945–6 not included.
[c] Camas—year 1945–6 only.
[d] Bear River—years 1943–4 & 1945–6
[e] Valentine—year 1945–6 only.
[f] Sabine—year 1945–6 only.

general opinion, however, is that "spring" skins are the most valuable. Some furriers prefer "late winters." In view of the increasing percentage of damaged skins that occurs when the highest percentage of "spring" skins are

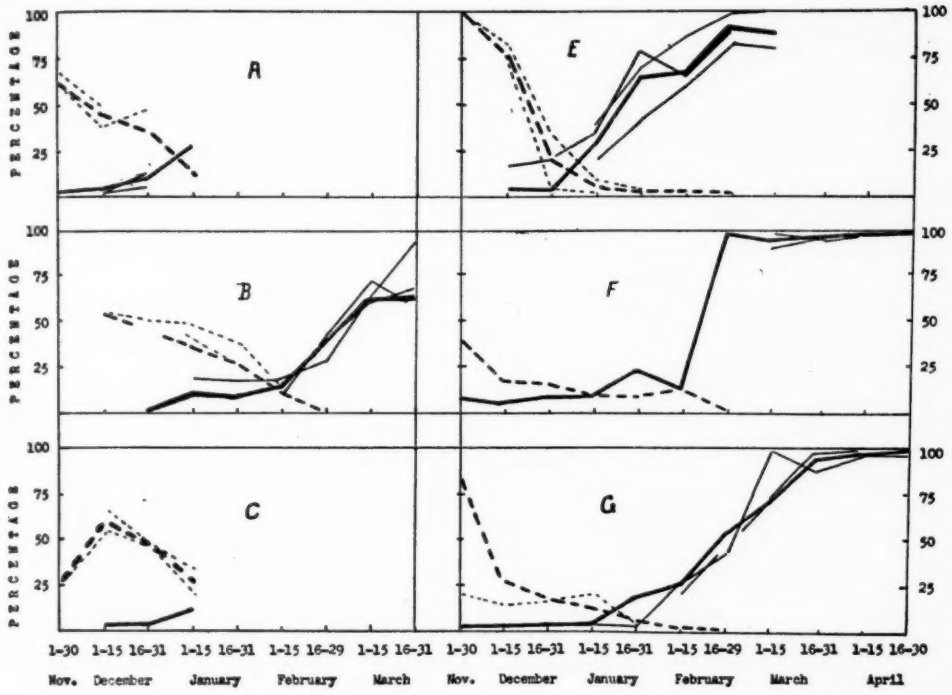

FIG. 1.—Percentage of "Fall" skins (broken line) and percentage of "Spring" skins from various sections of the United States by semi-monthly trapping periods. For each group, the heavier lines are 3-year averages and the lighter lines the annual variations if any. The percentage of "Winter" skins for any period would be the amount to equal 100 per cent above that of either or both the Fall and Spring. (See Table 5).

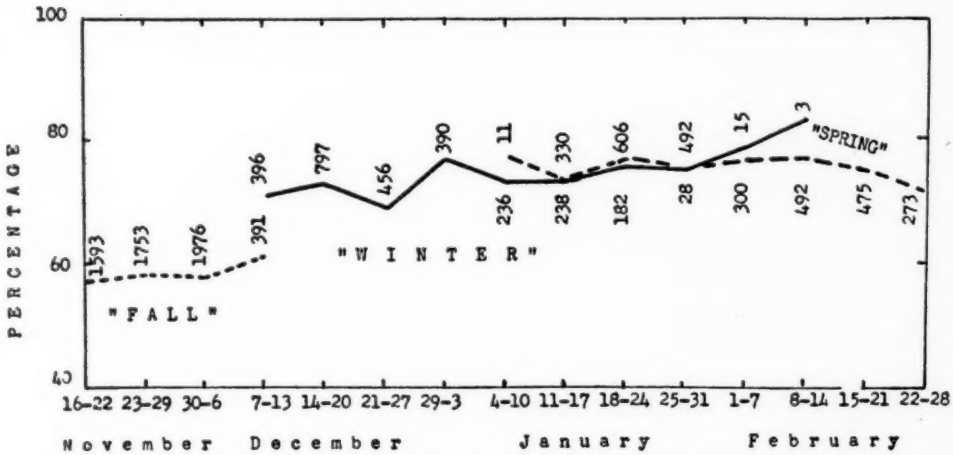

FIG. 2.—Muskrat pelts from Tule Lake Refuge, 1943–44. Average weighted percentage value per skin by period when trapped. Basis: XXX Large heavy fur spring = 100 per cent. Figures along graph lines are number of skins taken in each trapping period. (See Table 7.)

TABLE 6.—PERCENTAGE DISTRIBUTION OF DAMAGED MUSKRAT SKINS, KITS, AND MICE BY SEMI-MONTHLY TRAPPING PERIODS ON NATIONAL WILDLIFE REFUGES IN VARIOUS SECTIONS OF THE UNITED STATES. TOTALS OF THREE YEARS 1943–46,*

Trapping periods	Total skins	Damaged skins			Kits and mice	Total skins	Damaged skins			Kits and mice
		Slightly	Moderately	Badly			Slightly	Moderately	Badly	
	Refuges: Mud Lake (Minn.), Seney (Mich.), Necedah (Wis.), Horicon (Wis.)					Refuges: Malheur (Ore.), Tule Lake (Calif.)				
Nov. 1–30	14,269	5.6	1.7	0.6	1.6	5,199	1.6	5.6	1.1	1.6
Dec. 1–15	6,235	5.4	0.8	0.2	0.8	5,166	2.8	5.5	1.1	1.7
16–31	2,601	7.3	7.2	0.3	0.5	4,718	5.1	2.9	1.1	2.2
Jan 1–15	794	16.1	1.5	0.8	1.0	3,382	7.4	3.0	1.0	2.6
16–31	—	—	—	—	—	3,962	6.0	2.4	1.0	1.9
Feb. 1–15	—	—	—	—	—	6,380	14.3	4.2	1.9	1.8
16–29	—	—	—	—	—	4,049	15.9	3.8	2.9	1.6
Mar. 1–15	—	—	—	—	—	756	15.2	12.2	7.9	0.1
Totals	23,899	6.1	1.4	0.5	1.3	33,612	7.8	4.2	1.6	1.8
	Refuge: Montezuma (N. Y.)					Refuges: Camas (Idaho), Bear River (Utah)				
Nov. 1–30	—	—	—	—	—	399	10.8	2.5	1.0	2.0
Dec. 1–15	215	1.4	0.5	—	0.5	680	5.9	1.3	1.3	2.0
16–31	—	—	—	—	—	559	7.2	1.4	0.7	1.2
Jan. 1–15	1,806	6.7	1.1	0.2	0.3	340	4.1	0.9	—	0.9
16–31	2,257	6.0	0.4	—	—	180	5.0	—	—	—
Feb. 1–15	1,646	4.1	0.6	0.3	—	80	1.7	1.1	—	—
16–29	1,385	3.9	0.4	0.1	—	130	18.5	6.9	2.3	—
Mar 1–15	1,573	17.9	3.6	1.4	—	2,934	19.1	15.2	4.3	0.2
16–31	837	38.6	10.2	2.5	0.2	1,276	20.4	19.0	5.1	0.4
Totals	9,719	10.1	1.9	0.6	—	6,959	15.6	11.0	3.4	0.7
	Refuges: Squaw Creek (Mo.), Big Lake (Ark.)					Refuges: Lower Souris (N. D.), Sand Lake, (S. D.), Lacreek (S. D.), Valentine (Nebr.)				
Nov. 1–30	20	—	—	—	5.0	1,164	3.4	7.6	1.6	4.6
Dec. 1–15	1,569	2.2	0.7	—	6.3	2,139	4.9	1.3	0.5	5.0
16–31	1,655	1.6	0.2	—	3.7	1,734	4.2	1.2	0.2	1.5
Jan. 1–15	381	2.1	—	0.3	4.2	2,619	2.9	0.7	0.7	0.6
16–31	—	—	—	—	—	2,556	4.1	1.0	0.4	0.2
Feb. 1–15	—	—	—	—	—	1,449	3.8	1.0	0.3	0.8
16–29	—	—	—	—	—	1,694	6.3	1.3	0.5	0.3
Mar. 1–15	—	—	—	—	—	622	11.1	1.9	0.2	0.3
16–31	—	—	—	—	—	2,797	24.3	5.2	3.7	0.8
Apr. 1–15	—	—	—	—	—	3,191	22.1	17.7	3.7	0.2
16–30	—	—	—	—	—	575	25.7	12.5	7.3	—
Totals	3,625	2.3	0.4	—	5.0	20,540	10.5	4.9	1.6	1.2
	Refuges: Delta (La.), Sabine (La.)									
Dec. 1–15	14,476	3.8	1.7	0.6	4.5					
16–31	15,118	6.6	1.8	0.5	5.2					
Jan. 1–15	9,399	6.7	2.2	0.7	5.9					
16–31	15,966	7.3	2.1	0.6	5.4					
Feb. 1–15	13,380	8.6	2.6	0.7	5.6					
16–29	335	3.9	2.1	0.3	3.9					
Totals	68,674	6.7	2.0	0.6	5.3					

* Exceptions listed in Table 5.

obtained, the question arises as to what part of the trapping season will return the most net money to the trapper. Some information is available from this study but only on the basis of the relative estimated values of the grades of skins. This does not consider the difficulty of trapping operations because of the weather, which becomes an important factor when net profits are being determined.

On the basis of Table 7 the entire Government's share of muskrat skins from the Tule Lake Refuge for the season 1943–44 were weighted for size, quality, condition, etc., by weekly trapping periods. The appraisal values of the low grades at the time of grading were used to determine percentage values in relation to those of Table 7. An average skin-value was determined for each weekly trapping period on the percentage basis, considering the XXXL, heavy fur, spring skins as 100%. This is graphically displayed in Figure 2.

The average value per skin any time after January 1 was within 3% of the highest average value for any weekly period during the remainder of the trapping season. Skins taken during the last week of February had such a high percentage of damage that the average value per skin for that period was lower than during any weekly period since the last of December. The conclusion to be drawn is that at Tule Lake delaying trapping beyond the middle of January adds nothing to pelt values during seasons similar to that of 1943–44.

TABLE 7.—AUCTION COMPANY ESTIMATE OF RELATIVE PERCENTAGE VALUE OF ITS VARIOUS GRADES OF NORTHERN MUSKRAT SKINS. THE BASIS IS ON THE XXX LARGE HEAVY FURRED SPRING SKINS AS 100 PERCENT. THIS RELATIONSHIP MAY VARY FROM TIME TO TIME DUE TO CHANGES IN USE OF MUSKRAT SKINS. DAMAGED (OTHER THAN SLIGHTLY DAMAGED) AND OTHER "LOW GRADES" VARY SO MUCH THAT IT WAS NOT DEEMED ADVISABLE TO ASSIGN RELATIVE VALUES.

Grade	Heavy fur	Light fur	Light pelt	Slightly damaged
Spring				
XXX Large	100	85	92	87
XX Large	93	79	86	81
X Large	87	74	80	75
Large	80	68	74	70
Lge.-Med.	67	57	61	58
Medium	58	50	54	51
Small	45	38	41	39
X Small	33	28	31	29
Winter				
XXX Large	97	82	89	84
XX Large	90	77	83	78
X Large	83	71	77	73
Large	75	64	69	65
Lge.-Med.	63	54	58	55
Medium	53	45	49	46
Small	40	34	37	35
X Small	30	26	28	26
Fall				
XXX Large	80	68	74	70
XX Large	75	64	69	65
X Large	70	60	64	61
Large	65	55	60	57
Lge.-Med.	57	48	52	49
Medium	47	40	43	41
Small	30	26	28	26
X Small	22	18	20	19

A SURVEY OF OVER-POPULATED DEER RANGES IN THE UNITED STATES

Aldo Leopold, Lyle K. Sowls, and David L. Spencer

This survey was first undertaken for the purpose of compiling a country-wide map of deer problem areas for use in classes. There is no such map.

When the job was half done, it was mentioned to a meeting of deer men at the 1946 Wildlife Conference. This group asked that the findings be published. We were told that the findings, however crude, were needed in other states. Apparently deer men everywhere have found it hard to convince the average citizen, and especially the average deer hunter, that (1) delay in reduction of overpopulated deer ranges means ultimate shrinkage of both the herd and the range; (2) reduction is the only remedy, nothing else works; (3) to accomplish a reduction, female deer must be killed.

Our hope is that this imperfect history of the recent behavior of deer populations may convey the lesson that in managing overlarge herds, "too little and too late" is the worst possible policy.

Source of Data

Our data are gathered from the literature and by correspondence. We tried to find in each state someone posted on local deer. He was asked to map, classify, and date the areas of deer trouble.

The problem areas (black in Figure 1) are plotted upon a deer distribution map published by Gabrielson in 1943 (*Hearings, House Committee on Wildlife, p. 30 (Dec. 9–10)*), but modified in many states by more recent local maps published in cited papers.

We are indebted to our correspondents for their patient cooperation in this enterprise.

Errors

Appraisal of this technical problem by mail has undoubtedly led to errors both in our map, and in the later summary and classification of cases.

One error inheres in individual differences among our correspondents in viewpoint, knowledge, and freedom to talk. In some states the official policy is to minimize deer troubles, and in a few to deny their existence.

Another error inheres in seasonal shifts of deer. In the west, where the shift is usually altitudinal, only winter range is ordinarily mapped as in trouble. In the east, winter shift is so local that winter yards cannot be mapped separately except on very local maps. Thus Wisconsin alone has over 500 known yards. The result is that in a map like Figure 1, a given degree of overstocking "shows more black" in eastern than in western states.

In order not to obscure the black problem areas, Figure 1 is hatched on the vacant or near-vacant range, i.e., deer ranges are *white*. Boundaries of these white areas are very crude, and omit much fine detail because detailed distribution maps do not exist. The net result is that Figure 1 shows much more white area than is actually inhabited by deer. Some problem spots (black) appear on hatched (uninhabited) range. This is because the inhabited range is too small to map, and is coextensive with the problem area.

The most serious error is that we failed to get all of the salient facts about all problem areas, hence our classifications of history and status cannot readily be reduced to percentages.

ASSUMPTIONS

This paper proceeds on certain assumptions, which collectively may be called a theory of irruptions. We know of no way in which these assumptions may be proved or disproved at this time.

It is assumed, first of all, that deer irruptions are of recent origin, and that they differ from ordinary winter die-offs. The difference is that ordinary winter die-offs are sporadic in time, do only temporary damage to the range, are governed wholly by weather, and can occur at low-population levels. Irruptions, on the other hand, are cumulative in both timing and range damage, are governed only partially by weather, and occur only at high population levels.

It is assumed that the sequence of events first clearly recognized on the Kaibab, and later repeated in many localities in many states, represents the "normal" sequence of events in an irrupting herd. Departures from this sequence are assumed to have special local causes, such as herd reduction by special hunts, poaching, disease, or restoration of predator-pressure.

The Kaibab sequence was as follows:

1. Distress symptoms in palatable browse species.
2. Exhaustion of palatables, distress in inferior browse species.
3. Starvation of fawns in hard winters. Predation on weak fawns; scavenging on starved carcasses.
4. Exhaustion of inferior browse; consumption of worthless browse. Malnutrition, disease, parasites. Distortion of age-classes corresponding to fawn die-offs.
5. Starvation of adult deer in hard winters. Predation and scavenging as in stage 3.
6. New equilibrium between deer and range based on a reduced carrying capacity.

TERMS

The term "irruption" is unsatisfactory as applied to deer. Irrupting lemmings, grouse, quail, nutcrackers, and squirrels all exhibit excessive density followed by mass movement and no return of the movers. Deer, on the other hand, are conspicuous for their lack of movement despite excessive density. Many irruptions, especially of lemmings, are periodic, but deer irruptions certainly are not. Sudden and excessive density is thus the only common denominator. We use the term for deer because we know of no better one.

We found that at least three kinds of status had to be recognized in order to classify problem areas. These were defined to our correspondents as follows:

1. *Irruptive area.* An area in which the deer population has hurt the range by overbrowsing, or itself by malnutrition, or both. Any herd which must be fed to avoid starvation is in the irruptive stage.

2. *Trouble area.* An area in which the deer have recently exceeded the permanent carrying capacity of the range, but to a lesser degree than above defined as irruptive.

3. *Chronic area.* A problem area of long standing; an area in the post-irruptive stage (relapsed irruption).

We were sometimes unable to distinguish, by correspondence, between

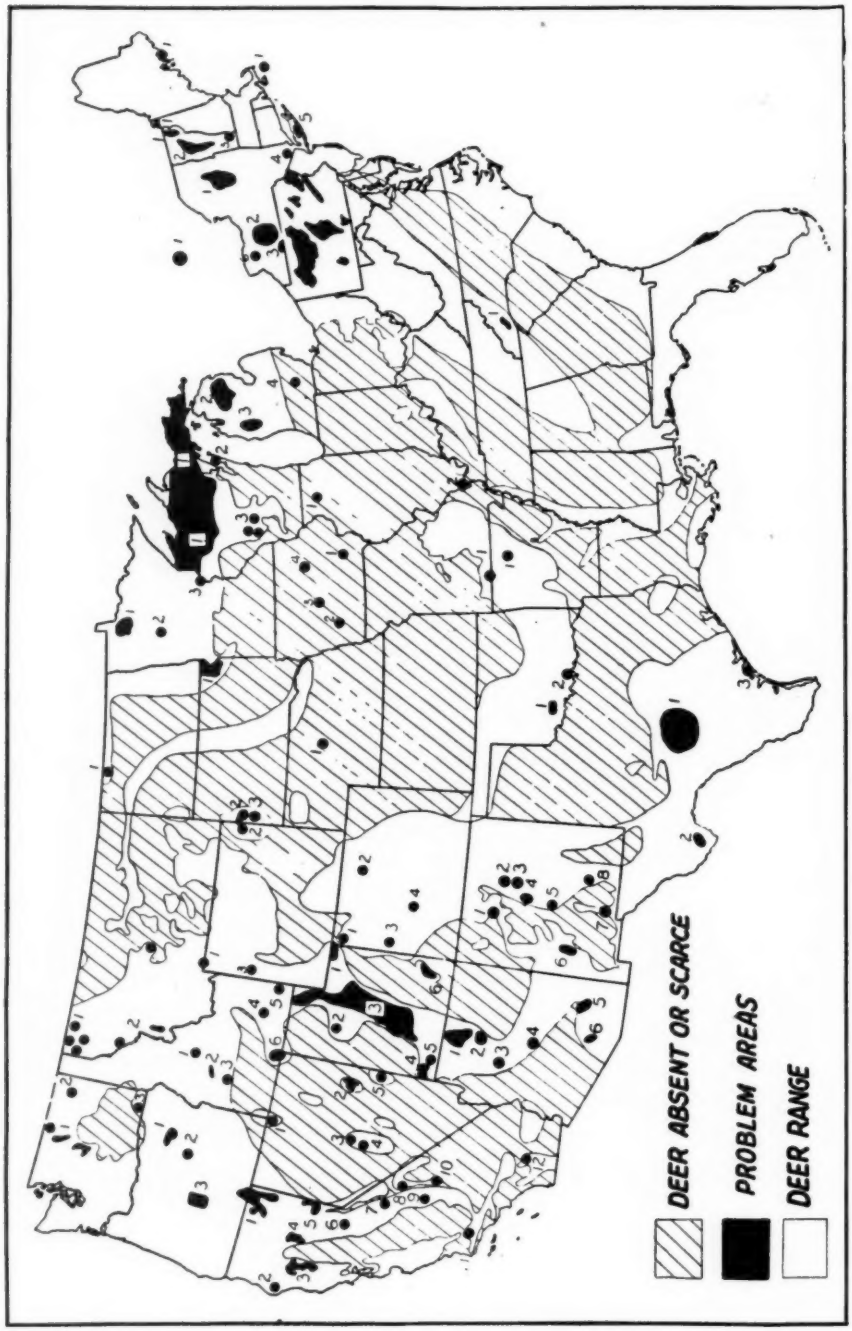

FIG. 1.—Areas in which over-populations of deer now exist or have existed in the recent past. Numbers refer to case histories.

old irruptions which had relapsed to a low population level, and trouble areas which had reached an equilibrium without passing through a starvation stage. Some examples of relapsed irruptions are Arizona 1, Maine 1, Wisconsin 2. Some examples of irruptions stabilized without violent starvation are Canada 1, Michigan 4, New York 6, Utah 4.

PROBLEM AREAS BY STATES[1]

ARIZONA

1. Kaibab (north). Mule deer. A relapsed irruption. Herd began to increase about 1910 from a base level of 4,000 deer. Peaked in 1924 at 100,000 deer. Reduced 60 per cent by starvation 1924–26. See *Rasmussen, D. I. Ecol. Monogr. 3: 229–275 (July 1941); also Leopold et al. Wis. Conservation Bulletin 8(8)1–11 (Aug. 1943).* Herd now at its lowest point since 1924 but range has all the deer it can carry.
2. Kaibab (south). Mule deer. Chronic area since 1926; "the major deer problem in the region." Local sentiment has blocked all efforts to reduce.
3. Woods Mt. Mule deer. Trouble area. History unknown.
4. Bloody Basin. Mule and whitetail deer. Range damaged, but recent investigations scribe this mostly to cattle.
5. Graham Mts. Whitetail deer. Irrupted in the mid 1920's, still high in 1929. Lions and perhaps starvation reduced herd to a low level by 1939. No problem now.
6. Tucson Mts. Desert mule deer. Trouble area, starvation impending during next dry year. See *Wells, Philip, Pittman-Robertson Quarterly 5(3)86 (July 1945).*

ARKANSAS

1. Sycamore District. Ozark N. F. Trouble, probably of recent origin, on two refuges totaling 14,000 acres.

[1] Numbers refer to locations in Figure 1. Known descriptive references are given in italics. Species are mentioned when not obvious from the geographic location. N. F. means National Forest; N. P. National Park.

CALIFORNIA

1. Interstate Herd. Mule deer. Increase began 1923, irruptive peak in 1936, high till 1944, sharp drop (from starvation?) in 1945. See *Fischer, G. A. et al., The Winter Range of the Interstate Deer Herd, Modoc N.F., Cal. U. S. F. S. mimeograph, Region 5, 20 pp. (1944).*
2. Humboldt Co. Columbian blacktail deer. Trouble area.
3. Glenn and Tehama Counties. Columbian blacktail deer. Chronic area since 1922.
4. Tehama Co. (east). Species? Assumed to be a trouble area, but details unknown.
5. Plumas and Lassen Counties. Mule deer. Irruptive, probably now at peak.
6. Eldorado Co. Species? Said to be a chronic area, but history unknown.
7. Yosemite. Mule deer. Chronic area. Some surplus removed in 1943. Trouble mostly confined to Yosemite Valley.
8. Inyo Co. (north). Mule deer. Trouble area, herd now increasing.
9. Sequoia and King's Canyon. Mule deer. Trouble area, some surplus removed in 1943, method unknown.
10. Inyo Co. (south). Mule deer. Said to be a chronic area, but history unknown.
11. Riverside Co. Mule deer. Chronic area, herd decreasing.

CANADA (NEAR BORDER ONLY)

1. Algonquin Park. Chronic overpopulation for 40 years. Both carrying capacity and deer have decreased gradually. No hunting. Wolves present, but only about 1 wolf per 1,000 deer.
2. Anticosti Island. (Off the map, therefore not shown.) Irruptive, perhaps chronic. Starvation frequent. Herd originates from planted stock. 1,000 deer killed yearly for meat but should be 6,000.

COLORADO

1. Dinosaur Nat'l. Monument. Irruption at peak for past two years over entire region of the monument.
2. Rocky Mt. N.P. Chronic area for many years. Surplus removed in 1944–45. Also overstocked by elk.
3. Kanna Creek. Trouble area since 1940.
4. Gunnison Co. Irruptive area, starvation and artificial feeding for many years.

See *Carhart et al, Deer-Elk Survey, Pittman-Robertson Project 4 R, Vol. 3 (1939), Vol. 6 (1941).*

IDAHO

1. Middle Fork, Salmon River. Mule deer. Chronic area with large die-offs in 1932 and 1943. Inaccessible to hunters by car.
2. South Fork, Payette River. Mule deer. Chronic area with large die-offs in 1932 and 1943. Heavy winter feeding of both deer and elk. Includes a 250,000 acre refuge. See *Varner, I. M., Bull. 8, School of Forestry, Univ. of Idaho, pp. 9–11 (1938).*
3. South Fork, Boise River. Mule deer. Irruptive area, peak in 1945.
4. Pocatello. Mule deer. Irruptive area, peak in 1945.
5. Montpelier. Mule deer. Irruptive area, peak in 1945.
6. Cassia. Mule deer. Irruptive area, peak in 1942.

ILLINOIS

1. Rockford. Irruptive area, high by 1940, heavy damage to woods by 1945. Herd winters on farm crops.
2. Horseshoe Lake Refuge. One buck and 3 does, planted in 1933, increased to 250 by 1944. Removals by trapping since 1938 reduced herd to present level of 150; 60 per year must now be trapped to maintain this level and prevent excessive crop damage.

IOWA

1. Skunk River Herd. Trouble area with 300 deer doing limited damage to farm crops.
2. Nishnabotna River Herd. Trouble area with 500 deer doing limited damage to farm crops.
3. Des Moines River Herd. Trouble area with 1,000 deer doing limited damage to farm crops.
4. Black Hawk County Herd. Trouble area with 100 deer doing limited damage to farm crops.

MAINE

1. Mt. Desert Island. Earliest recorded irruption in North America. Herd peaked in 1880; ice-storm in 1886 caused wholesale starvation. Again irrupted in 1920's, peaked in 1937, followed by sharp decrease. No hunting since 1905. See *Holmes, Laurie, Mount Desert Deer, Past and Present. 36 pp. (Privately published 1944).* Acadia N.P. on the Island, peaked in 1939, population now static and not excessive.

Other Areas. There are other areas in Maine which we are unable to classify because of diverging reports from our correspondents.

MASSACHUSETTS

1. Nantucket Island. Deer planted in 1915: herd peaked in 1930, now exterminated.

Other Areas. Widespread damage to forests has occurred in many areas, but we have no explicit local history.

MICHIGAN

Most of the Michigan deer range is irruptive, but the Upper Peninsula irrupted later and (so far) less violently than the Lower Peninsula. See *Bartlett, I. H., Whitetails, Bulletin of the Game Division, 64 pp. (1938).*

1. Upper Peninsula. Gradual steady increase for the past 20 years, with many local variations. Half the yards browsed out, with frequent starvation, by 1938.
2. Lower Peninsula. From a low in 1910, this herd irrupted to a peak in 1930 in the Turtle Lake region. From this focal point the peak spread out, mostly westward, covering the mapped area by 1945.
3. Lake County Area. Irrupted early, peaking in 1936.
4. George Reserve. (1,200 acre enclosure.) Four does and 2 bucks planted 1928, range showed distress by 1933, peaked at 213 in 1934, when removals began. Shot down to 75 by 1941, to 50 by 1942; held at 50 to present, reduction to 25 now proposed. See *Hickie, Paul, Michigan Conservation 7(3)6–7, 11 (1937).*

MINNESOTA

1. Red Lake Refuge. Formerly mule deer, now whitetail, which entered the region with early logging. Yards browsed out, starvation, and winter feeding by 1935–36. Present condition unknown. See

Manweiler, Jack, Minnesota's Deer Problem, Minnesota Conservationist (Oct. 1937).

2. Itasca State Park. Chronic area, pine reproduction gone by 1932, starvation by 1934–35, open season 1945 with kill of 42 deer per square mile. See *Fredine, Gordon, Proc. Minn. Acad. of Sci., 8: 41–49 (1940).*
3. St. Croix State Park. Irruptive area, more recent than Itasca. Opened to hunting in 1945.

MISSOURI

1. St. Louis Game Park. (1,400 acre enclosure.) Peak herd nearly wiped out in 1905 by "black tongue." Heavy population stocking maintained since 1932 by acorns and wholesale feeding. Browse plants wiped out. See *Dalke, P. D. and D. L. Spencer, Jour. Wildlife Mgmt., 8(1)1–6 (Jan. 1944).*

While this is the only present problem area, the Missouri deer herd is expanding so rapidly that there is trouble ahead unless the herd is kept shot down to range capacity.

MONTANA

1. Glacier N.P. Part of west side suffered heavy starvation losses prior to 1938. Herd since reduced to normal by predation.
2. Six Other Winter Ranges. Biennial Report for 1940–42 reports these ranges as overstocked (see map). Present status largely unknown. The most northeasterly area, in Meagher County, contains both mule deer and whitetail, and is in the early stages of trouble.

NEBRASKA

1. Bessey Division, Nebraska N.F. Mule deer. Trouble area, corrected by open season in 1945. Kill of 362 included 2 whitetails.

NEW HAMPSHIRE

1. Coos County. Density reported to be normal; deer die when logging kills ground hemlock and deep snow restricts movement. Perhaps not an irruption at all.

NEW MEXICO

1. Cuba. Trouble area. History unknown.
2. Pecos River (Senorita Refuge). Reductions by special hunts in 1943, 1944, and 1945, but still too many deer. Additional hunt for 1946.
3. Gallinas District, Santa Fe N.F. Irruption began 1939; relieved by special doe hunt in 1941.
4. Sandia Refuge, Cibola N.F. An irruptive area reduced by special hunts yearly since 1941. No deer problem at present.
5. Magdalena Division, Cibola N.F. A chronic area since 1939. Special doe hunts in 1942, 1944, and 1945, but still too many deer in 1946.
6. Black Canyon (Gila, N.F.). Mule and whitetail deer. A chronic area, overstocked as early as 1924. Doe hunt in 1939, but now again seriously overstocked.
7. Jornado Range. An incipient irruption checked by special doe hunts in 1942 and 1943. Browse now in good shape.
8. Sacramento Division, Lincoln N.F. Herd irrupted during the 1930's; special doe seasons in 1942 and 1943 failed to relieve pressure. Still too many deer. Complicated by mixed land ownerships.

NEW YORK

New York deer have shown three upsurges. The first was apparently local to the Adirondacks and occurred in the 90's. The second was general, and began about 1913, after the inauguration of the buck law. The third was most pronounced in the southern counties, and began in the late 1920's, presumably by drift from Pennsylvania.

1. Adirondacks. Chronic area since 1895. The *"First Annual Report of the Commissioners of Game and Forests" (1896)* describes all the earmarks of an irruption, viz: recent increase, overbrowsed range dependence on logging, starvation.
2. Ontario and Steuben Counties. A farming region; deer killed off by 1880, reinvaded by 1920, increasing up to doe seasons in 1941, 1943, 1944. Farm crop and browse damage still heavy. See *Cook, Dave, Jour. Wildlife Mgmt., 6(4)287–291 (Oct. 1942).*

3. Allegany State Park. Irruption peaked in 1939–40, when 500 starved; open season 1944, but range still overstocked. See *Shadle, A. R. and Donald Stulken, Jour. Wildlife Mgmt., 6(4)27–30 (Oct. 1942)*.
4. Bear Mt. State Park. Chronic since 1931. Frequent starvation. No reductions.
5. Suffolk County, Long Island. Chronic since 1932. A trucking region with heavy damage to crops.
6. Genesee County. A farming county adjacent to Ontario but not reinvaded until about 1930. Peak numbers 1935–40 with heavy crop damage but little browse damage. Deer were still eating ground hemlock but not white cedar in 1938. Open season 1944(?) removed 500; deer now scarce.

NEVADA

1. Santa Rosa. Irruption peaking in 1943. Doe hunt held in 1943.
2. Kingston Canyon. Irruption peaking in 1943. Doe hunt held in 1943.
3. Shell Creek. Irruption peaking in 1944.
4. Reese River. Irruption peaking in 1943. Doe hunt held in 1943.
5. Snake Division, Nevada N.F. Irruption peaking in 1942.

NORTH CAROLINA

1. Pisgah Game Preserve. A planted herd of mixed origin, nearly wiped out by "black tongue" in 1908. Increased from 1916 to irruptive peak and starvation in 1935–36. Special hunts after 1936. Disease again in 1939. Herd and range now both low. See *Ruff, F. J., The Whitetail Deer of the Pisgah National Game Preserve, U.S. D.A. Forest Service, 249 pp. mimeographed report (1938)*.

NORTH DAKOTA

1. Upper and Lower Souris Refuges. Whitetail deer. Rapid increase following establishment of refuges in 1935. Surplus removed by special hunts in 1941 (Lower) and 1943 (Upper Souris). See *Cook, F. W., Jour. Wildlife Mgmt., 9(3)237–242 (July 1945)*.

OKLAHOMA

1. Wichita Mts. Wildlife Refuge. Whitetail deer. Trouble area, probably an incipient irruption. Range carries elk and buffalo as well as deer.
2. Lake Murray State Park. Whitetail deer. Trouble area, possibly an incipient irruption.

OREGON

1. North Fork of John Day River. Chronic area. Range capacity reached in 1929. Herd increased to a peak in 1931 of 19,000 deer, 3,200 elk; then reduced by starvation in the winter of 1931–32 to 2,000 each. The population rose again and suffered another die-off in the winter of 1936–37. Recent conditions unknown. See *Cliff, E.P., Relationship between Elk and Mule Deer in the Blue Mountains of Oregon. U.S.F.S. Portland Oregon, Mimeographed report, 10 pp. (No date)*.
2. Murderer's Creek. Winter starvation noted in1934. A local refuge was abolished in 1935. Population increased to a peak in 1941. Herd was then reduced by hunting and starvation. Carrying capacity of range in 1943 estimated to be 20% of that in 1932. See *Mitchell, G.E., Trans. 9th N. Amer. Wildlife Conference. pp. 167–172 (1944)*.

Less severe deer troubles have occurred in the adjacent Malheur National Forest. Exact details unknown.

3. Klamath-Deschutes-Lake County Area. An impending irruption was noted in 1943–44 and corrected by a special doe season in 1945.

PENNSYLVANIA

There is a large literature on the Pennsylvania deer problem. For a recent summary account see *Gordon, Seth, Pennsylvania Bags 700,000 Deer in Ten Years. Outdoor America, 7(3)4–5, 8–9 (Jan. 1942)*.

The area shown on our map is copied from *Gerstell, Richard, The Pennsylvania Deer Problem in 1938, Pa. Game News, Part 1, 9(5)12–13, 31 (Aug. 1938); Part 2, 9(6)10–11, 27, 32 (Sept. 1938); Part 3, 9(7)6–7, 29 (Oct. 1938)*.

The state herd rose from 1,000 in 1905 to a peak of 1,000,000 head in 1928. By 1938 it had been reduced by hunting and starvation to 50 per cent of its peak level, with an accompanying 50 per cent depletion in range carrying capacity. The present herd stands at about the 1938 level. Range recovery is slow; it is still difficult to plant white pines.

SOUTH DAKOTA

1. Roberts County. Whitetail deer. A trouble area since 1943. Crop damage in winter.
2. Spearfish. Whitetail deer. An irruptive area reaching a peak in 1943. High winter losses in 1942–43. See *McKean, William T., Pittman-Robertson Quarterly, 3(4)201 (Oct. 1943)*. Also refers to Roberts County.
3. Harney National Forest. Whitetail deer. A recent trouble area, of which the eastern part has been chronic.

TEXAS

1. Edwards Plateau. Whitetail deer. A rapid increase in herd over past 15 years to a peak population about 1938. Large die-offs during severe droughts. See *Hahn, Henry C. Jr., The White-tailed Deer in the Edwards Plateau Region of Texas. Bulletin of the Texas Game, Fish and Oyster Commission, 52 pp. (1945)*.
2. Big Bend National Park. Mule deer. Heavy loss by disease in the past few years. Formerly overgrazed by stock.
3. Aransas Waterfowl Refuge. Whitetail deer. Herd has reached the carrying capacity. Surplus is being removed by trapping.

UTAH

Accounts of the Utah mule deer problems are found in *Rasmussen, D. I., Trans. 4th N. Amer. Wildlife Conference, pp. 236–243 (1939), and Doman, Everett R. and D. I. Rasmussen, Jour. Wildlife Mgmt., 8(4)317–338 (Oct. 1944)*.

1. Daggett. Irruptive peak reached in 1943.
2. Grantsville. Irruptive peak reached in 1939.
3. Wasatch Mountains. 21 problem areas nearly blanket the Wasatch Mountains, hence are mapped as one. They peaked as follows: 1930–34 two, 1935–39 eleven, 1940–45 eight. Present status: still in early stages 5, chronic (relapsed) 4, intermediate stages 12. Major starvations in 1935–36, 1938–39, 1941–42, 1942–43. Reductions by local controlled doe-killing almost yearly since 1938. Many areas complicated by elk, all by livestock problems.
4. Dixie. A peak of 16,000 was reached in 1936. Reduced to 9,000 by hunts from 1934 to 1942. Present carrying capacity estimated at 8,000. See *Olsen, Orange A., Jour. Forestry, 41(11)792–797 (Nov. 1943)*.
5. Zion National Park. A chronic area, which increased from a low prior to 1918 to a peak about 1936–37, when winter starvation began. Removal by trapping in 1938. See *Dixon, Joseph S. and E. L. Sumner, 4th N. Amer. Wildlife Conference, pp. 231–235 (1939)*.

VERMONT

See *Foote, Leonard E., The Vermont Deer Herd. Vermont Fish and Game Service, State Bulletin, Pittman-Robertson Series No. 13, 125 pp. (Aug. 1945)*.

1. Essex County. A chronic area.
2. Vermont Highlands. A trouble area, including local recent irruptive behavior in a few spots. Damage to crops.
3. Windham County. A recent irruption, now at peak or nearing peak; yards browsed out; first starvation 1945–46. Buck law since 1920.

WASHINGTON

See *McCauley et al., Washington Deer Report, Department of Game, Seattle, 44 pp. (1939)*.

1. East Cascades. Mule deer. Winter range areas are shown where irruptions have occurred since 1935. Some herds are decreasing. Over 50 cougars were bountied in Okanogan County in 1945–46.
2. Starvation Flat. Whitetail deer. Irruptive peak reached in 1942–43. See *Lockhart, Burton and L. M. Springer, Winter Deer Survey 1937–38. Dept. of Game, Seattle, typewritten report, 16 pp.*

3. Blue Mountains. Mule deer. A recent trouble area.

WISCONSIN

For a general picture of the Wisconsin herd see *Swift, Ernest, A History of Wisconsin Deer, Publ. 323 of the Wis. Conservation Dept., 96 pp. (1946).*

1. North Wisconsin. Herd increased greatly in last 10–20 years, reaching a peak about 1942. Fawn starvation noted in some yards by 1936; general starvation of fawns by 1942–43. 50,000 does were removed by hunting in 1943, but none since. The population is still too high. See *Leopold, Feeney et al., Wisconsin's Deer Problem. Wis. Conservation Bulletin 8(8) 3–22 (Aug. 1943).*
2. Chambers Island. A 3,000 acre island, chronic for perhaps 30 years. Starvation for many years. Browse plants wiped out. Herd kept alive by acorns and logging. 250 deer killed in 1945 by the Conservation Department. An estimated 100 head left. See *Wisconsin Conservation Bulletin, 10(11)3–5. (Nov. 1945).* Also *Feeney, W. S., Chambers Island Data. Wis. Conservation Bulletin, 11(1)6–9 (Jan. 1946).*
3. Camp McCoy, Necedah Refuge, and Saddle Mound. Three irruptive areas still increasing in 1946. First two closed yearlong, third open to bucks only. A few fawns died in recent hard winters; general starvation impending. Removal of 4,000 authorized for Necedah Refuge in 1946.

WYOMING

1. Yellowstone National Park. Mule deer. Possibly a chronic area, complicated by elk, in the north part of the Park. Heavy loss of deer by starvation in 1942–43. 700 elk were removed from this area in 1942–43 by the Nat'l Park Service; 7,000 elk were taken by hunting in the adjacent Montana area in the same season.
2. Black Hills. Whitetail deer. A trouble area, severely overbrowsed, and indicating critical conditions in the near future. See *Thomas, Gail M., Pittman-Robertson Quarterly, p. 186 (July 1942).*
3. Teton County. Mule deer. Possibly a chronic area with frequent winter losses over a long period. Details unknown.

ANALYSES

In the following analyses, the reader should bear in mind that without field work it was impossible for us to get all of the important facts about all problem areas, hence percentage classifications must guard against possible distortions. Nevertheless a few sound deductions can be drawn.

State Distribution. According to Figure 1, 47 states have deer, and 30 of these register trouble of some sort. There is only one deerless state: Kansas. There is only one region without deer troubles: the Southeast. Here screw worm and hound dog seem to perform the regulatory functions elsewhere delegated, often without success, to legislatures or conservation commissions. Many parts of the southeast could support more deer to the advantage of all concerned.

Species Distribution. All three species (whitetail, mule, and Columbian blacktail deer) exhibit irruptive behavior.

Time Distribution. Table 1 presents a chronology of such irruptive phenomena as are covered by the case-histories.

The column "New Increases" is incomplete because some of our correspondents did not know, and hence could not tell us, when a particular herd began to pyramid its numbers.

The column "New Peaks" is probably fairly reliable but for the variable size of the geographic units considered a "herd." (Thus northern Wisconsin, but for a few detached problem areas, is tallied as one herd, whereas in mountain states, a small mountain range is often recorded as a herd.)

"Starvation" is certainly low as compared with "new peaks" because the literature often mentions only the first starvation. Thus "frequent starvation since 1939" can be tallied only for 1939.

"Doe-killings" is believed to be somewhat low for the same reason: our correspondents often mention only the first or last reduction.

Table 1 is certainly valid in one respect: it shows an accelerating tempo in all irruptive phenomena and in remedial actions.

It is probably also valid in showing that the number of remedial actions is nearly as great as the number of new peaks. In short, few irruptions reaching the peak stage have been ignored by wildlife administrators.

Present Status. This of course raises the question: how nearly adequate have the remedial actions been? We tried to tally this, but believe the result to be too defective for publication as a table. We are, however, able to separate out two classifications which may have a degree of validity.

The present (1945) status of herds tallies out as follows:

Trouble areas with herd not yet at peak	22
Herds in first irruptive peak	32
Herds in second or later peak	4
Herds stabilized by reductions	13
Herds in chronic or relapsed stage	23
Herds died out entirely	1
Status unknown	13

The present status of the range (browse food) tallies out as follows:

Overbrowsing still bad	54
Overbrowsing partially relieved	45
Overbrowsing completely relieved	10

TABLE 1.—CHRONOLOGY OF IRRUPTIONS AND REMEDIAL ACTIONS.

Period	Number of			Number of reductions made by		
	New increases	New peaks	Starvation	Doe-killing	Trapping	Predators
1880–99	2	1	2			
1900–09	2					
1910–19	4	1				
1920–24	3	2	1		1	
1925–29	4	3	1	2	1	
1930–34	7	11	6	5		
1935–39	7	19	16	6	2	2
1940–45	15	15	15	35	4	
Total	44	52	41	48	8	2

These tallies seem to clinch the fact that despite the frequency of remedial actions, they have seldom accomplished the purpose of relieving overdrafts on the range. Only a tenth claim complete stabilization, and only half claim partial stabilization. One must conclude that the range goes down faster than the deer. Reductions, in short, are nearly always too late.

The tallies also show a few cases of repeated peaks, i.e. herds which have exhibited alternating peaks and starvations (Idaho 1 and 2, Maine 1, possibly New Mexico 6, Oregon 1). The more common aftermath of irruption, however, is a protracted low period in both population level and carrying capacity. Some of the most completely documented cases are in Table 2.

We have tried to tally the number of cases in which the bulk of the pre-irruptive carrying capacity was saved by prompt reduction. We have concluded that our data are too defective to answer this question but feel safe in saying that such cases are rare.

BEHAVIOR OF BROWSE PLANTS ON PROBLEM AREAS

Many case-histories exhibit similarities of food-plant behavior under deer pressure. Some of these are summarized below.

Critical Seasons. In cold climates the season of greatest food shortage is always winter, but in the low-altitude ranges of the Southwest, the critical season comes during the dry spring or summer. (Texas 1, Arizona 6).

Indicators of Pressure. Each region has particular plants, the behavior of which, under deer pressure, is diagnostic. Thus in Wisconsin, the earliest deer-line on balsam was the precursor of fawn starvation. On the Kaibab, eating pinon foreshadowed the catastrophic die-off of 1924–26.

Replacement. Probably the most important single fact in the ecology of browse plants is that as palatable species are crippled by overbrowsing, and as their reproduction is inhibited, their "place in the sun" tends to be usurped by unpalatable species. In short, deer pressure gives worthless foods a competitive advantage, and in the long run the whole flora tends to shift its composition in a direction unfavorable for deer.

Thus hemlock reproduction is a thing of the past in northern Wisconsin save only on certain Indian reservations and other deerless areas.

Effect of Artificial Feeding. There is general agreement that when deer are fed hay and grain, they do not, as a rule, stop browsing. Hence feeding seldom relieves an overdraft on the natural browse foods. A seeming exception exists in some deer herds in farming regions, subsisting on field crops. Some such herds do little browsing, even on heavily populated range, and even where crop damage is heavy (Iowa 1, 2, 3, New York 6).

TABLE 2.—RELAPSED IRRUPTIONS.

	Peak	Relapsed period to date	Present range condition
Arizona 1	1924	21 years	Fully stocked at 15% of peak level
Oregon 2	1941	4 years	Capacity 20% of 1932
Pennsylvania	1928	17 years	Capacity 50% of pre-irruptive capacity
Utah 4	1936	9 years	Capacity 50% of peak level

Mast, like grain, does not relieve an overdraft on natural browse foods. Underfed deer fatten quickly on mast, but mast is too irregular to maintain a herd on range which has lost its browse (Wisconsin 2).

Most irruptive states have tried feeding; a few (like Wisconsin) have been ordered to feed by their legislatures; none has found it a satisfactory remedy for overpopulation; a few (notably Colorado and Utah) state flatly that it injures both the deer and the range. (See *Doman, E. R. and D. I. Rasmussen,*

Jour. Wildlife Mgmt. 8(4) 318–338 (Oct. 1944).)

Effect of Cuttings on Browse. Down tops from current cutting operations often stave off starvation on overstocked ranges, but the end effect, like that of artificial feeding, is to aggravate the depletion of natural browse. Excess deer subsisting on down tops were recorded as early as 1895 (New York 1).

When cutting operations are sufficiently continuous, the result may be the annihilation of all woody growths accessible to deer. The Chambers Island herd (Wisconsin 2) evidently wintered for a decade on down tops alone.

Cuttings are sometimes made for the specific purpose of stimulating a new growth of browse-plants. (See *Morton and Sedan, Jour Wildlife Mgmt., 2(4) 206–214. (Oct. 1938).*)

Hilbert R. Siegler, Biologist for the New Hampshire Fish and Game Department, writes that "When softwood trees are removed by lumbering, ground hemlock (*Taxus canadensis*) disappears because of lack of shade. Deer in such localities are then forced to live on spruce. In years of severe snowfall, when their movements are restricted, a locality can then become over-browsed, and starvation sets in." This seems to be a reversal of the usual rule that lumbering increases browse food plants.

Spotty Damage. Starving deer do not disperse in search of food, nor has artificial dispersion by driving or baiting been successful. For this reason damage to range is usually spotty. There is a presumption, but no proof, that natural predators, by breaking up congestions, once tended to distribute the deer load more evenly.

The existence of unbrowsed spots on overbrowsed ranges is apparently universal, and is always confusing to laymen.

Masking. Mild winters frequently mask the over-browsed condition of the winter range by allowing deer to use the summer range in winter. This spreads the damage temporarily, but does not avert the ultimate penalty. It is hard to persuade the public that fat deer may, at times, be found on a depleted range.

"Storage." Long nearly-deerless periods often preceded the present irruptions of deer. This resulted in the accumulation or "storage" of palatable shrubs on a large scale. Thus parts of Wisconsin, Michigan, Pennsylvania, and New York accumulated heavy growths of ground hemlock (*Taxus canadensis*), one of the best of the palatable shrubs. These growths are now largely extirpated by irrupting deer.

"Stored" browse plants sometimes die with dramatic suddenness. W. J. P. Aberg, formerly Chairman of the Wisconsin Conservation Commission, tells us that Espinore Island, in Lake Huron, was a tangle of ground hemlock through a long deerless period. About 1939 the island was made a refuge. In about 1941 deer from the irrupting mainland occupied the island. In 1944 the ground hemlock showed little visible distress, but by 1945 it was mostly dead, and by 1946 it was all dead. Two winters of heavy overbrowsing wiped out the stand. White cedar on the same island is not yet injured, indicating the extreme palatability of ground hemlock.

Fortunately not all browse plants are so vulnerable to over-use as ground hemlock.

In the mountain ranges of the Great

Basin, such as the Wasatch and the Kaibab, there was large-scale "storage" of *Cowania* and *Cercocarpus*. This region was nearly deerless when Father Escalante traversed it in 1776–77; he had to eat his own horses or starve. (*Escalante's Journal, Utah State Historical Society, 11: 1–4 (Jan., Apr., July, Oct., 1943).*) It was nearly deerless when the Salt Lake region was mapped by Captain Stansbury in 1849–50. (*U. S. Senate, Executive Document No. 3, Special Session, 487 pp. (March 1851).*) It apparently remained nearly deerless until after 1910, and accumulated, in favorable spots, very heavy growths of *Cowania* and *Cercocarpus*. Nowhere in our travels have we seen so large a percenttage of palatable undergrowths as in this region.

This "stored" food doubtless contributed to the rapid growth of deer populations, peaking on the Kaibab in 1924 (Arizona 1) and on the Wasatch in 1932–43 (Utah 3). Conversely these immense herds made short work of the plants which had made them immense. Most of the plants remaining alive in 1941, when Leopold visited this region, had tops above the reach of deer. Those which had been killed had not yet been replaced by reproduction.

Closure. A decade or two after the inauguration of fire control, there is often a closure of tree crowns which reduces the amount of browse available at ground level, and hence the carrying capacity for deer. Intolerant palatables may be shaded out completely. Some palatables (like ground hemlock) are tolerant, but this shrub under deer pressure disappears so early that it hardly figures in the ultimate food crisis.

Closure has undoubtedly interplayed with other factors to aggravate irruptive phenomena. It is theoretically possible for a herd to starve without increase in density, if tolerant palatables are lacking and if closure is sufficiently uniform over its range.

The closed condition of the virgin forest is widely believed to account for the original scarcity of deer in many regions.

Behavior of Deer Populations on Problem Areas

Deer irruptions are possible because deer (and some other ungulates) differ from most other mammals, and from most birds, in social tolerance. When intolerant species become too dense they disperse, by their own social pressure, to other areas. If these areas are submarginal as habitat, they die.

When deer become too dense, there is no general dispersion, unless perhaps when forced by predator-attack. They become still denser, and eventually kill their food plants and starve.

Drift. While deer do not disperse from congested areas to a degree sufficient to relieve population pressure, there are always a few deer which detach themselves from the congested herd, and which show up, as drifters, on surrounding range. They are traceable only in farming regions where no other deer exist. Most drifters into farming regions fall victim to dogs, poachers, or motor accidents, but occasionally they take root and establish colonies.

Drifting deer began to show up on southern Wisconsin farms about 1930, which is also the time when the northern Wisconsin herd began to pyramid its numbers. Drifters now appear each year in many southern counties, and

where the per cent of woodlot area is greatest, large extensions of inhabited range have been made. No similar drift is known to have occurred before 1930, when the northern herd was low. The deer herds of the upper Mississippi and lower Wisconsin river valleys are of drift origin.

In Iowa drifters from the five local problem areas have been recorded from nearly every county in the state. Drift is known to occur in Michigan, New York, and Pennsylvania.

How to explain drift in so tolerant a species as deer is still an unsolved riddle.

Malnutrition. The malnutrition which follows the large-scale consumption of inferior browse causes a deterioration in both weight and antler development. (As an example see *Schunke, W. H. and Irven O. Buss, Trends in the Kill of Wisconsin Whitetail Bucks, 1936–40, Jour. Wildl. Mgmt., 5 (3) 333–336. (July 1941).*)

It is often difficult to tell whether poor antlers are caused by malnutrition, or the too-heavy shooting of prime bucks, or both. Over-shooting of prime bucks is frequent when buck-laws are unduly prolonged, and irruptions are also frequent under the same circumstances.

Appraisal of Areas. It is our impression that irrupting herds tend to act alike in the early stages of the "Kaibab-Sequence," but tend to become unlike in later stages. Hence an advanced irruption is often harder to appraise than an incipient one.

A common error is to try to appraise by census, rather than by browse conditions. The public can dispute endlessly about censuses, but it cannot dispute dead browse plants.

The appraiser should bear in mind that starved deer are always full of food, but the food is of inferior species. (See *Feeney, W. S., Wisconsin Conservation Bulletin, 8 (8) 12–19, (Aug. 1943).*)

The appraiser should bear in mind that no one irruptive stage is ever synchronous over large areas, and that the worst irruptions contain islands of normal range.

In Wisconsin, the present critical areas form a moth-eaten pattern, but in the Lower Peninsula of Michigan, critical conditions spread in more or less concentric zones from an initial focus on an over-preserved club at Turtle Lake.

PUBLIC EDUCATION

The deer literature exhibits singular unanimity on the difficulty of explaining over-browsing phenomena to hunters who are afield only in fall, and who seldom differentiate browse plants. Many writers agree that there are only two effective educational devices: field trips to winter yards, and exclosures where the difference between browsed and unbrowsed terrain may be seen.

CAUSES OF IRRUPTION

The irruptions known to us have been preceded by certain ecological conditions, and these have occurred so frequently as to raise the presumption that they constitute predisposing causes probably in combination with each other.

Predator Control. All western irruptions, beginning with the Kaibab, have followed, and none preceded, the initiation of federal predator control on the public lands about 1910.

In the east, the removal of effective deer predators came about earlier, and

irruptions also occurred earlier. Thus wolves are reported to have disappeared from the Adirondacks between 1888 and 1897; cougars in 1882–89. Both were too scarce to control deer for years prior to their final extirpation. The Adirondack deer first irrupted in 1895.

Again, on Mt. Desert Island, Maine, cougars disappeared about 1845, wolves 1863–80, and deer irrupted in 1880.

Irruptions are unknown in Mexico, and we know of only two in Canada. Both Canada and Mexico retain wolves or cougars, except in certain settled areas.

Since irruptions coincide both in time and space with greatly reduced predation by wolves or cougars, and since they are not known to have occurred in the presence of these predators, there is a strong presumption that over-control of these predators is a predisposing cause. In Europe, likewise, deer troubles began as effective predators ceased. (See *Leopold, Jour. of Forestry, 34: 4–5, (April–May 1936).*)

Many irruptions, beginning with the Kaibab, have occurred in the presence of numerous coyotes. The coyote may thus be ruled out as effective deer predator.

There has been a strong upsurge of coyotes in Wisconsin and Michigan since the recent onset of deer starvation in these states. It would be unsafe to conclude, however, that starving deer caused the increase, because the woods are also full of crippled deer, which die through the winter and furnish food.

Bald eagles and ravens have formed the habit of wintering on dead deer in parts of northern Wisconsin, and the search for carcasses is often facilitated by watching these birds.

Buck Laws. Does have been exempt from hunting, either by buck laws or by large closed areas, for a considerable period prior to all of the irruptions of which we have a record. States without recent buck-laws (like Minnesota) have irrupted only on large closed areas (like Itasca State Park, Minnesota 2).

Loggings and Fire. All eastern irruptions known to us were preceded by general logging, but long intervals sometimes elapsed before irruptions occurred. Presumably post-logging fires may have retarded the re-establishment of brushy growths. The evidence suggests that "brush in the sun" is the predisposing condition for large increments of deer food.

In the semi-arid west the forest is open, hence irruptions occur without prior loggings.

SUMMARY

Prior to the turn of the century, the prevalent population problem in deer was scarcity. Since that time, about a hundred herds of deer, varying in size from a small refuge to half a state, have pyramided their numbers to the point of presenting a problem. Of these, over half are known to have reached a population peak, nearly half are known to have exhibited starvation, and nearly half are known to have been reduced by legalized killing of females. The deer problem on most western ranges is complicated by livestock problems and often by elk problems.

Starvation occurs because the deer kill their natural food plants by overbrowsing. These are then replaced by plants of little or no food value. The post-irruptive carrying capacity has been estimated, in various cases, at

from near-zero to half of the pre-irruptive capacity.

The smaller deer starve first. Malnutrition, diseases, parasites, and predation on weakened animals accompany starvation.

Mild winters, artificial feeding, and down tops from logging often postpone, but never prevent, the ultimate shrinkage of both the herd and its range.

Buck laws, predator control, and over-large refuges, working in combination to allow undue multiplication of breeding females, seem to be the predisposing causes of irruptive behavior.

Prior loggings and fires, by renewing the plant succession, tend to increase deer foods on the eastern ranges. Fire protection later brings a sharp decrease in food supply when closure of the forest canopy shades out intolerant food plants.

Only about a tenth of the known problem areas are reported as stabilized as of 1945. Most of the remedial reductions have been too late, too light, or too intermittent to accomplish their purpose.

COMPUTING THE RATE OF INCREASE FOR DEER

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Excessive accumulation of deer in many localities in recent years has prompted some writers to study the birth rates in deer herds. The Kaibab Deer Herd is reported to have had an average annual rate of increase of 1.19 or a gain of 19 per cent (Rasmussen 1941). Some people have stated that a deer herd will increase by an addition of 25 to 35 per cent each year. These and other values are easily determined when the populations are known for the start and end of a given period of time. Naturally, the accuracy of the derivation is dependent upon the exactness of population counts.

Under certain conditions, populations of wild animals can now be counted with remarkable accuracy, as was demonstrated by Leslie Robinette and other personnel of the U. S. Forest Service. On the Fishlake National Forest in Utah they used the differential sex ratio method to count 66,000 head of deer with an error of about one per cent (Kelker 1944). Likewise, in the field of small game, Dr. P. F. English, assisted by Dr. Paul Dalke and the late Professor H. M. Wight, had an error of about 3 per cent over a two year period between the theoretical population and the actual population of pheasants on 1,280 acres of farmland in an excellent hunting area near Lansing, Michigan (English unpub.). Probably there are other censuses of like accuracy. Since it is shown that animals may be counted accurately, such data are proper to use in analyzing population growths.

This paper presents the method of calculating the value which represents the "average annual rate of increase." Even though this method is known to some wildlifers, a method not so well

known is the conversion of the latter value into the number of fawns per doe which exists in winter herds, and this number in turn converted to the survival number of fawn-births per adult doe.

The fastest rate of increase among deer herds so far reported is that originally present in the white-tailed deer herd on the Edwin S. George Reserve, an area administered by the Museum of Zoology, University of Michigan, and located near Ann Arbor. Because this herd is on a fenced area of nearly 1,300 acres it was possible to record all animals removed from the area as well as to find the very few dead ones. Thus later counts (in the opinion of the writer) corroborate the validity of the count of 160 head which resulted from a deer drive in the fall of 1933 (Hickie 1937). The 160 head increased from 2 bucks and 4 pregnant does released in the spring of 1928. Given the initial and final population for a given period of time, we can calculate the average annual rate of increase of these animals for the six-year period involved. Before doing the computations, we shall consider the derivation of the formulas.

THE MATHEMATICAL BACKGROUND

The derivation of the formula for game animals as used in this paper applies only to those which reproduce 12 months or later after their own birth. Thus mice and similar animals having two or more generations in one breeding season are excluded.

An aggregation of trout, pheasants, foxes, or deer in the post-summer season will consist of the offspring and their parents. We shall let the symbol A represent the number of adult animals in the group, and y the average number of young per mature female. The proportional number of mature females in A is found by the expression:

$$\frac{\text{mature females}}{\text{adult animals}} = f$$

which herein is called "the female fraction." Its derivation is usually based on a sample of the herd.

The value of f is ordinarily given as $\frac{1}{2}$, even though it may be an approximation. For example, a sex ratio of 47 males to 53 females gives an f value of 0.53 which is only a difference of 0.03 from 0.50 or $\frac{1}{2}$. Hence a slight departure from $\frac{1}{2}$ has negligible significance for short periods of time.

The product of A and f gives the number of mature females in the entire herd. Then the product of $(Af)y$ gives the total number of young in the herd. In other words, adults plus offspring may be represented algebraically by:

$$(A+Afy) \text{ or } A(1+fy).$$

Therefore, it is obvious that the population P for t-years ahead may be found by the formula:

$$P=A(1+fy)^t.$$

Since A represents the original number, the expression $(1+fy)$ in the formula represents the rate of increase of the herd or flock. Just as the financial rate of interest is given by the expression $(1+i)$ or $(1.0i)$, so does the term fy in game studies become the equivalent of i in financial computations. Instead of the 2 per cent or 8 per cent on invested money as the value for i, the equivalent value for fy in wildlife studies often is much higher, as we shall presently see.

Hence, the rate of increase of deer and other animals is expressed by geometrical formulas, not arithmetical ones. This distinction is necessary because the writer has found people confusing the rate of increase with the number of young. For example, a 2 per cent interest on $100 earns more increment than 2 per cent on $50, yet the rate of interest (1.02) is identical. Similarly the rate of increase in deer may be identical for different increments of offspring.

The expression $(1+fy)$ does not truly represent deer and other big game because there are yearlings, or even two-year olds, which are not sexually mature. Thus the herd contains adults and their present offspring as well as an older age class of offspring. This deviation is partly taken care of by letting the expression

$$(1+fy)=r=\text{rate of increase.}$$

The substitution of r into the above formula gives:

$$P=Ar^t$$

Thus r can be solved for any past condition of the herd, but its application into the future is a close approximation, as may be demonstrated.

When t has a value other than 1, the solution of the formula for an unknown term is best done by logarithms. The unknown term solved for is usually r whenever we wish to know something about the past history of the deer herd; but in a prediction of future numbers arising under present conditions, the unknown term is P after t has been assigned a definite value. A solution for r will now be demonstrated.

ANALYSIS OF THE GEORGE RESERVE DEER HERD

The original number of deer (2♂, 4♀) released in the George Reserve needs to be changed to an even sex ratio because the formula is based upon an even sex ratio occurring in the offspring. The writer has discovered (unpub.) that if only bucks are killed the herd is reduced annually by 10 per cent to 30 per cent but the rate of increase is the same. Hence, the correction factor must be applied to A, not to r. This assumes r to include an even sex ratio whether or not such a condition exists in the adult group; for removing a portion of the male population does not in any degree influence the rate of increase. But if female deer are also killed, then the rate of increase is reduced, oftentimes making for a greater reduction in the population a few years ahead than does the killing of bucks. Neither of these two cases apply to the original stocking of 6 head on the George Reserve, and the succeeding 6 years of its complete protection. If the value of A were given as 6 head, it would mean a sex ratio of 3 to 3, and one female would be omitted from the calculations. In order to have the 4 females and an even sex ratio, 2 "ghost" males will need to be added to the first and last populations. This is justifiable because they have nothing to do with the rate of increase.

Substituting the revised figures in the first formula and solving[1] for r we have:

$$r=1.651$$

[1] The solution is:

$$162=8r^6$$

$$\frac{\log 162-\log 8}{6}=\log r$$

$$\log r=0.217738$$

$$r=1.651$$

Therefore the average annual rate of increase of the George Reserve deer herd over its first 6 year period was 1.651. In other words, the growth of the herd had an interest value of 65.1% compounded annually.

In doubling the value of the 65.1 per cent we obtain the number of fawns per doe. (The term doe includes the yearling females.) Therefore the doe-fawn ratio is 1:1.302. The explanation for doubling is as follows (when $f=\frac{1}{2}$):

Given:

$r=(1+\frac{1}{2}y)$; and $r=1.651$

Hence:

$$1.651=1+\tfrac{1}{2}y$$

$$y=\frac{1.651-1.000}{\frac{1}{2}}=1.302$$

The doe-fawn ratio is readily obtained by field observations during the hunting season or later. Having obtained this ratio, and inserting the fawn number into the expression $(1+\frac{1}{2}y)$, we may calculate the value for the rate of increase for that year. Therefore, given one term the other may be derived.

The number of fawns per doe existing in the winter herd may be further analyzed to give an index to the minimum value of fertility for the herd. Fertility is the average number of fawn births for each sexually mature doe. Thus, ratio of fawns to breeding does must exclude sterile yearling females which were present in the summer herd. We first get the winter ratio which is all females older than fawns compared to fawns. The next step is to eliminate the yearling females, which then gives the ratio of mature females to fawns as existing in the summer season. The ratios for both groups were formulated from life equation tables developed similarly to Leopold's (1933, p. 455) by the writer (Unpub.). Given an even sex ratio and no losses, the summertime ratios y' may be compared to the wintertime ratios y as follows:

Average number of fawn-births per adult doe in summer	*Fawns present in winter for each doe, yearling or adult (close approximation)*
0.5	0.4
1.0	0.7
1.5	1.0
2.0	1.3

Given any wintertime count of fawns per doe (see right column above) and by means of interpolation from this table, we may derive the number of survival fawn-births per adult doe which exists in the winter herd. (This is the value in the left column.) A large number indicates a high fertility of the herd, as was demonstrated in the case of the George Reserve herd. On the other hand a low value denotes either a low fertility or a medium to high fertility beset by unusual losses from the action of predators, disease, or other factors. Thus a value for high fertility, up to the time of investigation, indicates healthy reproductive functions as well as a suitable environment; contrarywise, a low value indicates that something is wrong either with the reproductive functions of the animals or in the animal community. In either case an investigation is urgent.

It is evident that the George Reserve deer herd had an exceptionally high survival value of 1.302 fawns for each doe. The maximum value possible may be derived from a known case of even sex ratio, no losses, and two fawn-births per adult doe. Such information is given on page 455 of Leopold's "Game Manage-

ment" (1933) in the table entitled "Species Bearing First Young at 2 Years." Examination of the table reveals that in 6 breeding seasons the original pair increased to 42 head. By the use of the second formula we find:

$$42 = 2r^6$$

$$r = 1.661$$

and $$y = 1.322$$

Therefore, in a new herd, the highest doe-fawn ratio for the winter season is 1:1.322. The correction for the maximum fertility value as indicated in the above table would have it read 1.322 instead of 1.3. The computed value of the George Reserve deer herd almost equals it. Such a high doe-fawn ratio in wintertime is the result of a very high birth rate. So we may conclude that the fertility of the George Reserve deer herd for 6 years averaged exceedingly close to 2 fawns being born to each adult female in the herd.

Such unusual reproductiveness for six consecutive seasons seems improbable. However, if a female had only a single fawn, then the second one of twins must be accounted for by one of two ways—either several adult females had triplets, or many yearlings at the age of 12 or 13 months each gave birth to an offspring. Either case is an unusual occurrence. However, the latter condition has been reported in New York (Cheatum and Morton 1942). As not more than 6 groups of triplets were observed during this early period,[2] and many single fawns were noted each summer, it is circumstantial evidence that such a high rate of increase was maintained only by some of the fawns becoming pregnant in the fall, and dropping an offspring the following spring or early summer.

The last calculation above for r gave a value of 1.661 or 66.1 per cent addition each year. If fawns do not become pregnant, and triplets are very rare, the value of 66.1 per cent represents the absolute maximum of deer herd increases. However, even this value cannot be attained under the stated conditions if the herd has run through many generations. Again referring to Leopold's tables, the 42 head increases to 754 in the next 6 years. The rate of increase is 1.618. This lower value is due to the biological condition of having a greater proportion of sterile yearling females in the latter herd than in the former. Therefore, the approximated value of 62 per cent (not 66 per cent) is a practical one for using as the base when comparing the rate of increase in wild herds with the maximum rate possible.

STUDY OF OTHER HERDS

In contrast to the George Reserve deer herd which is characterized by a rapid increase over a very short period of time, an Oregon herd exhibited a slow rate over a very long period of time (Cliff 1939). It was subject to hunting during its later development. The population estimates were 3,100 head in 1921 and 19,500 head in 1931 which a heavy starvation loss reduced to 8,600 before spring arrived. The herd again increased to 20,000 head by 1938. The values for rate of increase and net fertility tell a new story when calculations are made for two short periods and

[2] Reported to the writer by the custodian of the area.

the combined long period. The solution gives these results:

	Rate of increase (r)	*Fawns per doe (winter)*	*Net survival of fawn-births per adult doe*
1921 to 1931	1.202	0.404	0.49
1931 to 1938	1.128	0.256	0.26
1921 to 1938	1.116	0.232	0.22

Two interesting facts are revealed by these calculations. First, the growing healthy herd had an annual net increase of 20 per cent, but following the heavy winter die-off, the net annual increase was almost 13 per cent. The reduction is a result of net fertility values being lowered almost one-half from 0.49 to 0.26 fawns per adult doe. The second noteworthy feature pertains to the time element in the method of calculation—that the rate of increase of the last 7 years is but slightly larger than the over-all period of 17 years. Hence, it is evident that calculations covering a long growth period may mask some catastrophe to a herd which, in the absence of annual field investigations, may be discovered only by the use of short time periods in the calculation of r.

It must be remembered that the computed value of fawn-births per adult doe may or may not represent the full value for fertility. In these calculations the true number of fawn-births is greater than the derived values because losses of young fawns are bound to occur in the first few months of life. Hence, the so-called "fawn-births per adult doe" actually shows the annual net gain to the herd. In short, it represents "fertility minus all losses."

Another herd that built up to high numbers lives on a portion of the Cache National Forest in northern Utah. In 1917 only 250 head were reported, but in 1939 the population was estimated at 6,000 head as a result of numerous drives (Doman and Rasmussen 1944). From this information we compute these values for a 22-year period:

rate of increase = 1.155
annual gain = 15.5 per cent
fawns per doe = 0.310
fawn-births per adult doe = 0.4 (net survival)

These values are associated with a buck removal, and light winter losses in the last 5 years. Heavier winter losses have since occurred, so one may suspect that, similarly to the Oregon herd, the fertility became lower than two decades ago.

In contrast to the computed rates of increase of growing herds, let us consider the rates of a shrinking herd. The Kaibab deer herd had an estimated population of 20,000 head reported in 1930 and 10,000 head estimated in 1939 (Rasmussen 1941). The rate of decrease may be found, but obviously the doe-fawn ratios and fertility values cannot be computed. The same formula is used as before to solve for r:

$$\frac{\log\ 10{,}000 - \log\ 20{,}000}{9} = \log r, \text{ or}$$

$$\frac{4.000000 - 4.301030}{9} = \frac{89.698970 - 90}{9}$$

$$\log r = 9.966552 - 10$$

$$r = 0.9259$$

Because this value of r is less than 1 we shall use the more descriptive term "rate of survival." If 92.6 per cent of the herd survives, then 7.4 per cent of the breeding herd, plus the equivalent

of all fawns born, were lost each year over the 10-year period.

The four-step method herein developed is applicable to all big game animals which are delayed only one year in breeding. Excepting the last step, the method may be applied to pheasants, rabbits, and other small game. In their case, the value of y denotes fertility. The expression $r = (1+fy)$ was originally designed for this latter group of animals.

SUMMARY

When the population of any group of animals is known at the start and end of a known period of time, the data may be analyzed to give the average annual rate of increase. Then by inspection of the computed value one may read the per cent gained annually. When this second value is doubled, there is obtained the number of young per female. In the case of deer and other big game, this latter value is identical to the count of fawns per doe which is so readily obtained in winter counts. Because big game herds include the sterile yearling group, a corrected value must be interpolated from a prepared table to give the survival number of fawns per breeding female. The fourth step in the computations on populations may give an index to the fertility of the herd. Such computations are now possible since census methods have been developed to give accurate counts on deer herds. Our calculations have shown annual increases of 11 per cent to 20 per cent, a reported one of 19 per cent, and a computed value of 65 per cent. The biological maximum for deer is 66 per cent annually, but in wild herds it cannot exceed 62 per cent. Therefore, when yearling females are sterile, the maximum rate of increase for deer herds is 1.62 compounded annually.

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BRIEFER ARTICLES

A METHOD FOR THE YEAR-TO-YEAR MEASUREMENT OF MAST YIELDS

On areas where continuous wildife studies are made it is frequently desirable to measure quantitatively the food supply available to various species each year. The annual mast crop is particularly subject to variations and, at least in the northern states, this food supply is a vital factor in determining the condition and survival of squirrels and other animals. At the Rose Lake Wildlife Experiment Station in Clinton County, Michigan, a method has been devised which gives reliable figures on nut production for use in year-to-year comparisons.

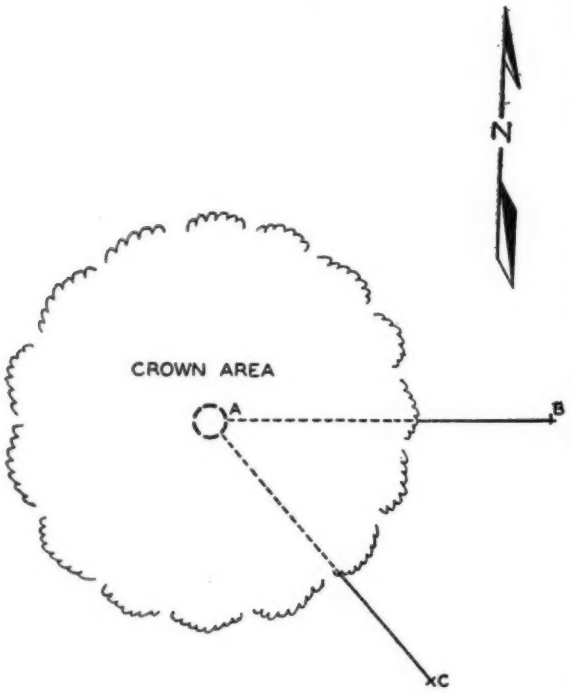

FIG. 1.—Diagram of sampling method.

Early in this work we tried sampling the mast crop by the use of square-meter quadrats marked out in the woodland and under trees in the open. Nuts were periodically gathered from the quadrats, and from these samples the yield of entire trees was calculated. The method proved to be unsatisfactory. The unit was so small that laying out the number of samples necessary to give a significant figure on trees of low yield became unwieldly. Locating the quadrats under trees with relation to crown edge and calculating the crown area proved to be difficult to standardize. A sample large enough to give significant results with only a few scattered nuts on the ground involved more labor then necessary when used on a tree with an abundant crop. Direct comparisons of woodlot trees with trees in the open were subject to considerable error because the yield of one woodlot tree was inseparable from that of others around it. In the case of hickories, at least, the small crop borne on many woodlot trees is used by squirrels while the nuts are green, and few reach the ground to be measured. Much of the mast used by animals in fall and winter is borne by trees growing in the open, and since these exhibit the greatest yearly variation, they are most easily used in obtaining an annual index of mast production.

With such considerations in mind a technique was devised for use on isolated trees. It standardizes as many variables as possible and saves labor by varying the per cent of the crown area used as a sample under a given tree according to the frequency with which nuts are distributed in that area. It gives a production index for each tree which appears to be a reliable basis for comparison. Its main advantage is the ease with which it can be applied, since there are doubtless other methods by which satisfactory results can be obtained.

The trees used for sampling were fully crowned and growing in open situations such as fencerows and pastures. They were tagged and numbered and a card file set up by species. The same trees are being used each

year. Ten trees of each of the important mast-bearing kinds have been considered an adequate number at Rose Lake.

Trees are prepared for sampling before the nuts begin to fall. A heavy fence staple is driven into the base of the trunk on the east side of the tree (A, fig. 1). A cord is then run through this staple to a stake (B) beyond the outer limits of the crown directly east of the trunk. Depending upon the size of the nut crop, an estimate is then made of the per cent of the crown area that must be used to give a reliable figure on the total yield. This area is calculated in terms of degrees of a circle, and a large wooden protractor, made for the purpose, is used to lay off the proper angle with another stake (C) on the south side of the tree. For example, if a 12.5 per cent sample were considered desirable, as in fig. 1, the second stake would be placed beyond the edge of the crown directly southeast of the trunk so that a cord from it to another staple in the tree trunk would describe a 45 degree angle with the cord running to the east. The angle is so measured that the lines represented by the two cords would intersect at the center of the tree. In case of a very sparse nut crop and a small tree, it might be desirable to take as much as half the crown area to get a nut sample large enough to be measured accurately in quarts. The year 1942, when this method was first applied at Rose Lake, was a fairly good mast year, and the sample size for most trees was 8 to 10 per cent. The white oaks largely failed, and the average sample for 11 trees of that species was 16.6 per cent of the crown.

The gathering of nuts within the plots under the selected trees must start as soon as the fruit begins to fall and continues until the tree is bare. The nuts are husked and measured in quarts and the total yield for each tree calculated from the sample. Weekly intervals appear to be suitable for gathering nuts inside the sample areas. It is evident that there will be some loss to rodents; but no nuts are gathered under a mast-sampling tree except those needed for the work, and it seems likely that animals would be most attracted to those spots under the crown where mast is most plentiful. If this is true, the sample plots would be least visited. Also the fact that the trees are in open situations causes them to be less frequently visited by squirrels. Rodent activities are an unavoidable complication in nearly any kind of mast measurement, but the factor is present every year and this should tend to mitigate the errors. Occasionally nut trees of certain species do not drop their fruit in the fall. In particular it has been noted that the fruits of small-fruited hickory (*Carya ovalis*) are occasionally persistent. One of the trees in 1941 held practically the entire crop until February. In such a case it is impractical to use that particular tree.

It is evident that the method described gives a total yield figure for the tree which would be accurate if all sides bore equally and the tree were perfectly symmetrical. Calculated yields probably are slightly greater than actual yields because the standardized sample is taken on the side of the tree where insolation is greatest. However since the method is standard from tree to tree and year to year the figures obtained offer a comparison sufficiently free from significant variables to suit the purpose.—DURWARD L. ALLEN AND HOWARD D. MCGINLEY, *Game Division, Department of Conservation, Lansing, Michigan.*

A USEFUL NESTBOX DESIGN

In old and ill-tended forests, there are usually enough dead limbs and hollow trunks, both standing and fallen, to fill the needs of wildlife for dens and nesting places. But, in younger forests and on areas where most of the woods have been cleared off, defective trees are weeded out and fallen ones salvaged, so that hole-nesting species are hard put to find places in which to live and rear their broods. Where cavities are scarce, the wildlife manager can encourage a considerable number of species, both birds and mammals, by providing man-made houses to supplement the natural supply. The use of such

devices to attract birds is an ancient custom; the placing of nest boxes for the improvement of wildlife habitats is of relatively recent origin. Artificial homes may be put up to attract song and insectivorous birds (Kalmbach and McAtee, 1926), to improve opportunities for the breeding of game birds and mammals (Hesselschwerdt, 1942, Brown and Bellrose, 1943) or to increase the numbers of certain insectivorous mammals (Hamilton and Cook, 1940).

All too often, houses intended for one kind of wildlife are usurped by another. The occupancy of bluebird houses by starlings and English sparrows is all too frequent, as is their use by bees, wasps and hornets. Hawkins and Bellrose (1941) noted a combination of competition and predation between wood ducks, for whom their boxes were intended, and wasps, raccoons, squirrels, screech owls, honey bees and snakes. Hesselschwerdt (1942) reports seven kinds of wildlife using 56 den boxes, while Brown and Bellrose (1943) found eleven kinds in 800 boxes. I have had eight different forms using a group of 20 houses.

To be accepted by wildlife, boxes must be of suitable dimensions and the size of the entrance hole must be a proper one for the species to be attracted. Kalmbach and McAtee say that "a well-built bird house should be durable, rain-proof, cool, and readily accessible for cleaning." Hole-nesting birds and mammals will use almost any sort of house if it meet these modest requirements, *provided it is properly located.* In my experience, placement is the most important factor in determining whether or not a box will be occupied. No matter how well designed and soundly built, improperly located boxes attract few occupants—and empty houses produce no new generations of wildlife. Unfortunately, humans and wildlife do not appraise location of a nest box on the same basis, so only *some* proffered boxes will be accepted. With enough time and patience, good places could be discovered but a quicker and perhaps surer way is to erect many houses and so make up with sheer numbers for errors in site selection.

The cost of a few houses, no matter how elaborate, may be unimportant. But as soon as we expand our field of operations to cover considerable areas of farm and forest, we must produce our nest boxes in quantity and at low cost. Many of the designs shown in the older books are models of craftsmanship, but their building would require much time and no mean skill. In labor and materials, each house would cost several dollars, a prohibitive price if they are to be used in quantity. For mass production, boxes must be of simple design and must require only such materials as are readily available. For twenty years I have been experimenting with houses for small birds and mammals. Out of this experience has come a design which, if not flawless, has many advantages and few shortcomings.

The material for a small nest box, a California-type orange crate, can be had for the asking at the grocery store. These crates are made of soft pine and, without the cover, consist of three heads ($11\frac{1}{2} \times 11\frac{1}{2} \times \frac{5}{8}$ inches) and six slats ($4\frac{3}{4} \times 26 \times \frac{3}{16}$ inches). If carefully taken apart, it will supply almost all the lumber and nails for three boxes. A few brads, staples, screws, scraps of roofing paper, bits of wire and a little extra wood complete the bill of material, for which the cash cost will be less than 10 cents per unit.

Because all the angles in the design are either 90° or 45°, cutting can be done rapidly on any small power saw. The thin material permits the sawing of several pieces at one time. With minor exceptions, the nailing is through the thin and into the thick member, which makes for a firm structure. The wide, overhanging, pitched roof protects the whole structure from the rain. The cleats keep the box away from its supporting tree or post, which keeps the box both dry and sound.

Each box takes two slats and one head, plus two back cleats and a bar for the bottom of the front. The working drawings show how to lay out the work and cut the material. Front and back are cut from one slat, the sides from the other. Part of the head supplies the mask and the bottom, the remainder makes the roof. Back cleats and bars must be cut from extra heads. Roofing can be picked up as scrap. A piece of stiff wire, as from a coat-hanger, supplies the latch.

Cut the front (11 inches) and the back

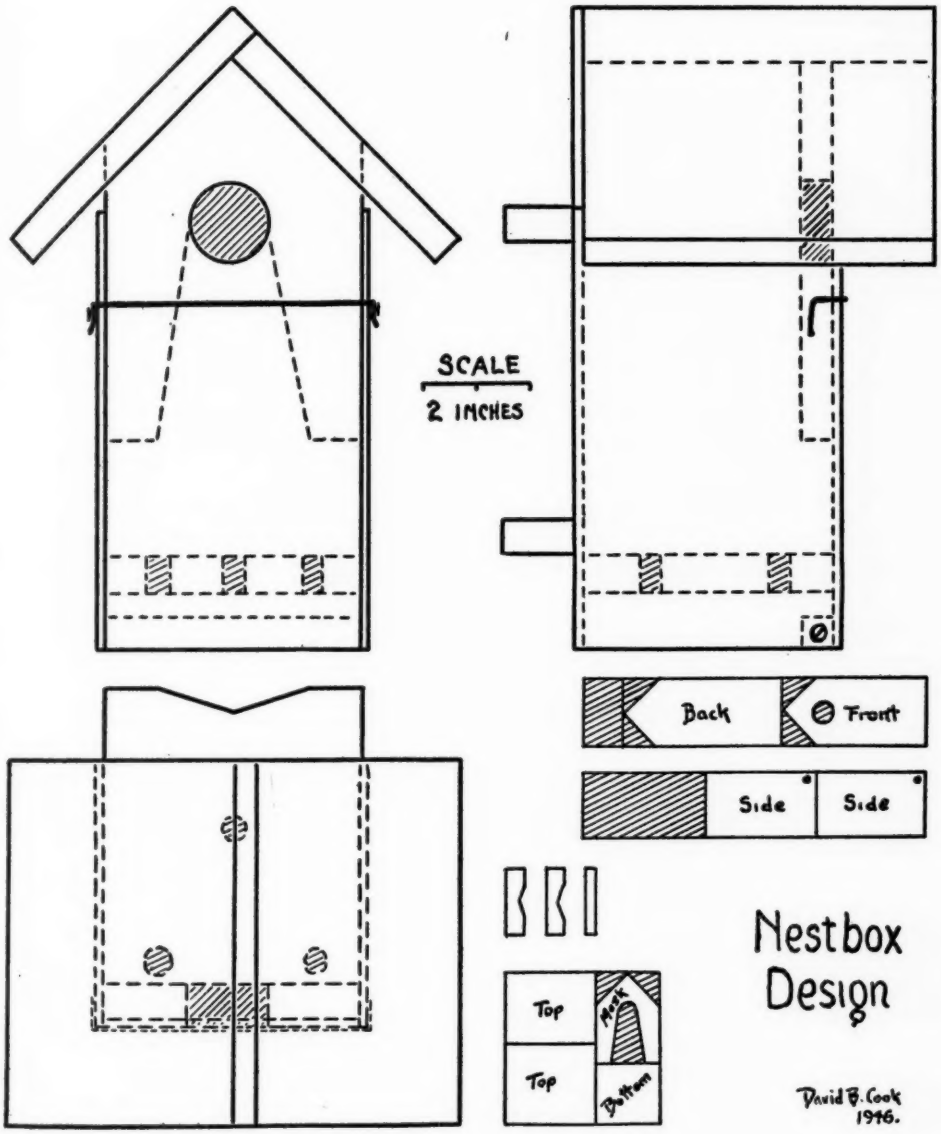

FIG. 1.—Design for construction of nesting box.

(12 inches) to length. Lay the front square with one corner of the head and tack lightly with a couple of ¾-inch brads. Place the back on top, in similar position. Rip the head along the edge of the slats. Cut the peak on all three pieces at once. Unfasten the back and bore the entrance hole through both front and mask. Remove the front. Bore the drain holes in the bottom, measure and saw off. Rip out the mask, but save the cut piece. Saw the top in two, as indicated. Cut two sides to size, bore holes for the hinge screws.

Cut two cleats and one hinge bar (¾-inch square).

To assemble, screw the back to the cleats. Nail the two parts of the roof together. Nail the back to the bottom, then to the roof. Place the sides in position, fasten to back and bottom. Wedge the cut piece back into the mask (so as not to split the mask in nailing), nail the mask to the roof and sides, in proper position so that, when the front is in place it will close flush. Let the upper nail on each side protrude ¼-inch, to catch the latch. Nail the front to the hinge bar, put in place, insert hinge screws. Bend, fit and staple the latch, being sure the staples are well clinched so as not to interfere with closing. Tack on the roofing. Bore attachment holes through center of each cleat. Pull the wedge out of the mask and the house is ready to be put up.

The box can be secured to a support by two 1½-inch screws put through the holes in the cleats. Most of my boxes have been erected at eye-height, which makes for easy inspection and cleaning. Houses used for small mammals should be carefully checked. Mice and squirrels often alternate between homes and it is best not to dump out nest material until certain that the box is not in use. Easy inspection facilitates such checking.

A coat of paint is a good preservative and will lengthen the life of the house considerably. But it is not essential and the cost of labor and material is almost as much as that of building another house. Painted and unpainted houses have been used with equal success. Some of my unpainted boxes have weathered eight seasons of New York's erratic weather with no apparent deterioration. Color is a matter for the human eye; the wildlife appear to be entirely indifferent in the matter. Greens and browns are inconspicuous and render the box less liable to human meddling, but one of my most successful houses is painted yellow, with a bright red roof.

Houses built to this design have proved adequate for most of the smaller hole-nesting species. Bluebirds, tree swallows, chickadees and house wrens, flying squirrels, red squirrels and deer mice have all used them successfully. During the summer, unused boxes are often taken over by wasps. One of my nest boxes, on the dead stub of an old apple tree at the edge of the woods, harbored five broods of bluebirds and two of tree swallows in the course of six summers, besides housing deer mice each winter.

Where larger forms of wildlife are to be encouraged, the design can be enlarged, once and a half vertically and twice horizontally, making a box large enough for squirrels or wood ducks. These bigger sizes require somewhat thicker lumber, which can be had from the standard one-bushel fruit box, which is about 20×11×12 inches.

How, then, does this wildlife house design measure up? It is simple and rugged. It can be built from standard materials that can be readily had from salvage. The cash cost should not exceed 10 cents per box. It has a tight and permanently-attached roof, good drainage, adequate ventilation. By opening the front, the contents can be examined without disturbing either the nest or its occupants, a point of major importance where research work is in progress. Cleaning is quickly and easily done.—DAVID B. COOK, *New York Conservation Department, Albany, New York.*

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PULLORUM DISEASE IN THE COOT

Among specimens collected on March 8, 1945, at Buckeye Lake, Ohio, were a number of coots (*Fulica americana*). When the latter were examined for parasitic infection, it was noticed that the ovary of one specimen was deformed, and much enlarged when compared with those of other birds of this species collected on the same day. No other lesions were detected macroscopically, and the bird appeared to be in normal physical condition. The ovaries resembled those found in chickens affected with pullorum disease, and a pure culture of *Salmonella pullorum* was recovered.

Since coots around farm ponds may associate closely with domestic fowl, they could easily be exposed to the infection from such a source.

Pullorum disease has previously been recorded from a number of wild birds, but this is the first record from a member of the family Rallidae. It is not known how commonly this species is affected with the disease; by macroscopic examination only, one bird was infected among 19 adult females examined.

We are indebted to Dr. Harry Weiser, Dept. of Bacteriology, Ohio State University, for confirmation of the diagnosis.—ROBERT RAUSCH, *Dept. of Bacteriology and Public Health, Michigan State College, East Lansing, Michigan.*

SUGGESTIONS FOR THE HANDLING OF CERTAIN MAMMALS

For experimental work, it is often desirable to handle the smaller wild mammals more freely than usual methods allow. Howell (Jour. Mamm. **18**(4): 513, 1937) suggests the feeding of pentobarbital sodium in milk or other food. While this may be satisfactory for animals accustomed to captivity, it can hardly be used for those newly captured.

In trapping a number of mammals for infection experiments, box traps being used for this purpose, the captured animals were driven from the trap into a mesh sack. While thus restrained, pentobarbital sodium solution was injected intraperitoneally, and within a short time the animals would become either unconscious or sufficiently narcotized to allow the desired amount of handling. The recommended dosage of 1 cc. (containing 1 grain of pentobarbital sodium) per pound of body weight was used. The weight could only be estimated in the field, but in no case was there any undesirable result; a few animals remained unconscious for a longer period of time than was necessary.

No attempt was made to make the injections aseptically. The animals were kept for a considerable time after their capture, and none showed any evidence of introduction of infection by the needle, either while alive or when autopsied. This method was used on raccoons, woodchucks, fox squirrels, and cottontails.

In order to avoid the odor another method was used for skunks. Avoiding unnecessary disturbance, the door of the trap was opened, and the skunk induced to enter a cardboard carton through a small opening in the side of the latter. The opening was then closed and either chloroform or ether poured through a small opening in the top. As soon as it was evident from lack of movement that the animal was unconscious, it was removed. The several skunks handled by us did not eject any scent under these circumstances.

Both methods were adequate for our work, and it is assumed that they are equally applicable for other purposes.—ROBERT RAUSCH, *Department of Bacteriology and Public Health, Michigan State College, East Lansing, Michigan.*

REVIEWS

The Mammals of Michigan. By William H. Burt. Ann Arbor, University of Michigan Press. xv+288 pp., 13 pls., 107 figs., 67 maps. 1946. $3.50.

This volume brings down to date the knowledge of Michigan mammals. The author is Curator of Mammals in the Museum of Zoology at the University of Michigan and already has made numerous contributions to the literature in several fields of mammalogy. The present book is addressed to the lay public and schools of Michigan to provide a general summary of the state's mammals. For this purpose it should do well, being written in a pleasant readable style largely free of technical terms. The general brevity of treatment, averaging about 3 pages per species, is supplemented in part by the many illustrations and by some of the tabulated information at the end of the work.

Introductory chapters deal briefly with the history and economic values of Michigan mammals, and with adaptive radiation and territoriality generally among mammals. The methods of collecting and preparing specimens are described at some length. There are illustrated keys for identifying the mammals from skins or fresh specimens and from skulls, together with a glossary of terms used in the keys. There is also an outline of the classification of mammals of the world to families, following mainly that of Simpson (1931).

The systematic portion (pp. 79–266) includes characterization of all groups represented in the state, from subclasses to subspecies, and discusses 67 Recent species; of these a few are extinct and others far reduced. The individual species accounts are rather brief and conventional: measurements, description, skull, habitat, distribution, habits, and economic status. The geographic range in Michigan and the general range in North America of each species are shown by maps. Each is shown in a natural pose by either a line or colored drawing mostly from life, the work of R. P. Grossheider. The book contains no photographs. References to literature are scattered in the chapters and species accounts, there being no general bibliography. A terminal table (IV) gives, by species, a summation of measurements and life history data—gestation period, number and size of litters, longevity, and home range.—TRACY I. STORER.

Prairie Wings. Pen and Camera Flight Studies. Edgar M. Queeny. Explanatory sketches by Richard E. Bishop. Ducks Unlimited, Inc. New York. 256 pp. 1946. $15.00.

Kip Farrington's "The Ducks Came Back —The Story of Ducks Unlimited"[1] left many readers, including myself, with the feeling that one book about DU was about enough. In such readers the news of a second book, this time published by Ducks Unlimited and written by one of its Board of Trustees, evoked something less than whole-hearted enthusiasm. I hasten to testify that the present volume is the antithesis of the former one in every important respect, and that it may be read with delight by any conservationist lucky enough to lay hands on it.

"Prairie Wings" deals with the poetry and the aero-dynamics of duck flight.

Too often the esthetics of any given natural phenomenon are treated by one group of men, and its technology by another. Too often each group is abysmally incompetent in the field of the other. To Edgar M. Queeny, author and photographer of "Prairie Wings," and Richard E. Bishop, its illustrator, goes the rare distinction of equal competence in both fields. There are 256 delightful pages in this book, and on each page these authors teach the reader something new about the beauty and the science of flying fowl. Let no old duck hunter think he knows all about whistling wings until he has read this volume, and studied its photographs and drawings. "Prairie Wings" not only revives imperishable memories of mornings on the marsh,

[1] Reviewed by the writer in the Journal of Wildlife Management for July, 1946, pp. 281–283.

but it crams the mind with points to look for in the flights to come.

Knowing no aerodynamics myself, I cannot judge Mr. Queeny's, but the modesty of his assertions in this technical field leads me to suspect that the assertions are sound. He evidently sought and used the counsel of aerodynamic engineers.

Modern technology has much to answer for in the ruthless destruction of natural beauty, but even the most jaundiced observer of technical "progress" must admit that in such photography as Mr. Queeny's, beauty becomes immortal. Bird motions so rapid that they are not even visible to the unaided eye are here portrayed for leisurely enjoyment throughout the year. I cannot avoid the conclusion that perhaps the only vicious thing in modern technology is the kind of people who wield its gadgets, and think they are civilized for this reason.

Dick Bishop's drawings, which are used to point up and clarify what the reader might otherwise fail to notice in the photographs, are so good that any mallard might well shake his feathers in applause.

I can find only one fault with this book: its price. To those who cannot afford to buy it my advice is: get to work on your local librarian.—ALDO LEOPOLD.

Audubon Bird Guide. Eastern Land Birds. By Richard H. Pough, illustrated by Don Eckelberry. New York, Doubleday and Company, Inc. xxxvii+312 pp., 48 pl. 1946. $3.00.

It is probable that no instrument has had so profound and constructive an influence on the attitude of the general public concerning nature in its broader aspects than has the bird guide. Many professional wildlife workers obtained their initial field stimulus in the company of one of the old Reed Guides. Many guides have been published throughout the years, each serving its purpose. The present one is a worthy successor to those which have preceded it.

The prefatory remarks in the Foreword are more inclusive than in other books of a similar nature, including pertinent information on such subjects as the area involved, scope of the work, use of names, differences in appearance due to season, sex, and age, behavior of birds, field instructions, local and regional distribution, habitat and territorial needs, seasonal movements, economic relationships, conservation of birds, and lastly information on organizations interested primarily in ornithology.

The area covered by this handbook " . . . (some five million square miles) is in eastern North America north of Mexico, excluding East Greenland. The line dividing eastern from western North America is taken as the eastern edge of the semi-arid Great Plains, where the tall-grass prairie country meets the drier short-grass plains." The general treatment of each species does not differ widely from that in other handbooks, being divided into sections on identification, habits, voice, nest, and range, which sections, for the purposes of the book, appear to be adequate. The 48 colored plates are bound together in the middle of the text. They are all in color and are excellently done. Such books as this are often given hard usage, and the binding of the plates in the center may be of advantage in protecting them from the fate which often overtakes the outside pages in much used publications. And this one will be much used.—HARLOW B. MILLS.

Fruit Key to Northeastern Trees. William M. Harlow. Syracuse, N. Y. Published by the Author. 50 pp. including 140 halftone illustrations. 1946. 50¢.

This booklet, printed by the offset process, is, as its name indicates, largely composed of keys. According to the author, "The key is intended to serve not only in the identification of the fruits, but also as an instructional medium. For this reason most technical terms used are explained parenthetically." Wildlife workers in the northeast may find this handbook useful in some food studies.—HARLOW B. MILLS.

The Handbook of Game and Fish Management. Walter A. Gresh Published by the author, Box 121 Traffic Station, Minneapolis 3, Minnesota. No date, unpaged. $4.00.

This handbook is a lefax sized pocket book of about 100 photolithed pages, divided into

the following sections: Fiscal, Licenses and Permits, Administration, Maps, Fish, Lands, Waterfowl, and Miscellaneous. There is no text or introductory matter, the entire work consisting of tables, charts and maps, most of which have been copied directly from various federal and state conservation agency publications.

The maps are not always well reproduced, and are sometimes inaccurate. For example, a map giving the range of deer in the United States does not indicate the species, but lumps them all together, and another map, showing the distribution of "pheasant," ignores the occurence of pheasants in California where they are becoming a major management problem.

The section on fish contains an original item, a table showing the spawning seasons of various fish, "Compiled from the literature. . . . " The rest of the fish section consists of maps and diagrams reproduced from the recent publication, "Fishery Resources of the United States" (Senate Document 51, 79th Congress). The selections appear to be arbitrary, and some important fisheries are omitted.

Such important aspects of wildlife management as upland game, range management and predation are omitted. Some of these omissions may have been mechanical, as 22 pages were inadvertently left out of the first copies by the binder.

In spite of some omissions and inadequacies, the basic idea of this handbook is sound. According to the title page, additional matter is to be added from time to time, and the binding is of a loose leaf type to make such additions possible. However, the binding should have been of more sturdy construction, for the present binding does not appear durable enough to stand opening more than a few times, especially in damp climates where rust is the great enemy of all such metal devices. It is hoped that future editions will be more complete and up to date, and that a better type of binding will be used. It should be of some standard type so that personal material and notes can also be added. In particular, more care should be used in placing dates on the tables, for undated information on wildlife populations is of little value.—JOEL W. HEDGPETH.

NEWS NOTES

Attention should be called to the change in address of the Editor of the Journal noted on the inside of the front cover. All manuscripts for inclusion in the Journal and correspondence relating to editorial matters should be addressed in the future to Harlow B. Mills, Editor, Journal of Wildlife Management, Illinois Natural History Survey, Urbana, Illinois.